TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Arsenic

In the

Nonconnah Creek Watershed (HUC 08010211)

Shelby and Fayette Counties, Tennessee

FINAL

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TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

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LIST OF ABBREVIATIONS

CCC	Criteria Continuous Concentration
CFR	Code of Federal regulations
CFS	Cubic Feet per Second
CMC	Criteria Maximum Concentration
DEM	Digital Elevation Model
DWR	Division of Water Resources
EPA	Environmental Protection Agency
GIS	Geographic Information System
HUC	Hydrologic Unit Code
LA	Load Allocation
LDC	Load Duration Curve
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
NHD	National Hydrography Dataset
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
PLRG	Percent Load Reduction Goal
RM	River Mile
TDEC	Tennessee Department of Environment & Conservation
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WCS	Watershed Characterization System
WLA	Waste Load Allocation

SUMMARY SHEET

Total Maximum Daily Load (TMDL) for Metals in Nonconnah Creek Watershed (08010211)

Impaired Waterbody Information

State: Tennessee
Counties: Shelby, Fayette
Watershed: Nonconnah Creek (HUC 08010211)
Constituents of Concern: Arsenic

Impaired Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN08010211001 – 0100	HORN LAKE CUTOFF	16.4
TN08010211001 – 2000	HORN LAKE CREEK	5.2
TN08010211007 – 1000	CYPRESS CREEK	18.2

Designated Uses:

The designated use classifications for waterbodies in the Nonconnah Creek Watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation.

Water Quality Targets:

Derived from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, 2007 Version* for recreation use classification (most stringent):

Toxic Substances:

The waters shall not contain toxic substances, whether alone or in combination with other substances, that will render the waters unsafe or unsuitable for water contact activities including the capture and subsequent consumption of fish and shellfish, or will propose toxic conditions that will adversely affect man, animal, aquatic life, or wildlife. Human health criteria have been derived to protect the consumer from consumption of contaminated fish and water. The water and organisms criteria should only be applied to those waters classified for both recreation and domestic water supply. The criteria for recreation are as follows:

Compound	Water & Organisms Criteria * (ug/L)	Organisms Only Criteria (ug/L)
Arsenic (c)	10.0	10.0

(c) 10-5 risk level is used for all carcinogenic pollutants.
* These criteria are for protection of public health due to consumption of water and organisms and should only be applied to these waters designated for both recreation and domestic water supply.

TMDL Scope:

Waterbodies identified on the Final 2012 303(d) list as impaired by arsenic.

Analysis/Methodology:

The Arsenic TMDLs for impaired waterbodies in the Nonconnah Creek Watershed were developed using a mass balance approach. For arsenic, the water quality criterion for recreational use was used as the target concentration. The target concentration for each metal was used to develop a flow-based TMDL. 10% of the TMDL was reserved for a margin of safety. The remaining 90% of the TMDL was available for Waste Load Allocations and Load Allocations. The TMDLs, WLAs, and LAs for arsenic are summarized in the following table.

Critical Conditions:

Expression of water quality criteria and TMDLs as an equation accounts for all conditions, including variance in flow.

Seasonal Variation:

The 10-year period used for WinHSPF model simulation period for development of duration curve analysis included all seasons and a full range of flow and meteorological conditions.

Margin of Safety (MOS):

Implicit (conservative modeling assumptions) and explicit (10% of the water quality criteria for each individual metal for each impaired subwatershed).

Summary of TMDLs, WLAs, and LAs expressed as daily loads for Arsenic Impaired Waterbodies in the Nonconnah Creek Watershed (HUC 08010211)

HUC-12 Subwatershed (08010211__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	PLRG	WLAs	LAs [b]
						MS4s [a,b]	
			[lbs/day]	[lbs/day]	[%]	[lbs/day/ac]	[lbs/day/ac]
0201	Cypress Creek	TN08010211007 – 1000	$5.39 \times 10^{-2} \times Q$	$5.39 \times 10^{-3} \times Q$	60.0	$5.587 \times 10^{-6} \times Q$	$5.587 \times 10^{-6} \times Q$
0301/0302	Horn Lake Creek	TN08010211001 – 2000	$5.39 \times 10^{-2} \times Q$	$5.39 \times 10^{-3} \times Q$	23.1	$1.303 \times 10^{-6} \times Q$	$1.303 \times 10^{-6} \times Q$
	Horn Lake Cutoff	TN08010211001 – 0100					

Notes: Q = Mean Daily In-stream Flow (cfs).
PLRG = Percent Load Reduction Goal to achieve TMDL.
NR = No reduction required.

a. Applies to any MS4 discharge loading in the subwatershed. Future MS4s will be assigned waste load allocations (WLAs) consistent with load allocations (LAs) assigned to precipitation induced nonpoint sources.

b. WLAs and LAs expressed as a “per acre” load are calculated based on the drainage area at the pour point of the HUC-12 or drainage area.

ARSENIC TOTAL MAXIMUM DAILY LOAD (TMDL)
NONCONNAH CREEK WATERSHED (HUC 08010211)

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not meeting designated uses. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991a).

2.0 WATERSHED DESCRIPTION

Portions of the Nonconnah Creek Watershed lie in two states: Mississippi and Tennessee (see Figure 1). This TMDL addresses only impaired waterbodies in Tennessee. For the purposes of TMDL development, waters flowing into Tennessee from Mississippi are expected to meet Tennessee water quality standards at the state line. The Nonconnah Creek Watershed lies within two Level III ecoregions (Mississippi Alluvial Plain and Mississippi Valley Loess Plains) and contains three Level IV ecoregions as shown in Figure 2 (USEPA, 1997):

- The **Northern Holocene Meander Belts (73a)** within Tennessee is a relatively flat region of Quaternary alluvial deposits of sand, silt, clay, and gravel. It is bounded distinctly on the east by the Bluff Hills (74a), and on the west by the Mississippi River. Average elevations are 200-300 feet with little relief. Most of the region is in cropland, with some areas of deciduous forest. Soybeans, cotton, corn, sorghum, and vegetables are the main crops. The natural vegetation consists of Southern floodplain forest (oak, tupelo, bald cypress). The two main distinctions in the Tennessee portion of the ecoregion are between areas of loamy, silty, and sandy soils with better drainage, and areas of more clayey soils of poor drainage that may contain wooded swamp-land and oxbow lakes. Waterfowl, raptors, and migratory songbirds are relatively abundant in the region.
- The **Bluff Hills (74a)** consist of sand, clay, silt, and lignite, and are capped by loess greater than 60 feet deep. The disjunct region in Tennessee encompasses those thick loess areas that are generally the steepest, most dissected, and forested. The carved loess has a mosaic of microenvironments, including dry slopes and ridges, moist slopes, ravines, bottomland areas, and small cypress swamps. While oak-hickory is the general forest type, some of the undisturbed bluff vegetation is rich in mesophytes, such as beech and sugar maple, with similarities to hardwood forests of eastern Tennessee. Smaller streams of the Bluff Hills have localized reaches of increased gradient and small areas of gravel substrate that create aquatic habitats that are distinct from those of the Loess Plains (74b) to the east. Unique, isolated

fish assemblages more typical of upland habitats can be found in these stream reaches. Gravels are also exposed in places at the base of the bluffs.

- The **Loess Plains (74b)** are gently rolling, irregular plains, 250-500 feet in elevation, with loess up to 50 feet thick. The region is a productive agricultural area of soybeans, cotton, corn, milo, and sorghum crops, along with livestock and poultry. Soil erosion can be a problem on the steeper, upland Alfisol soils; bottom soils are mostly silty Entisols. Oak-hickory and southern floodplain forests are the natural vegetation types, although most of the forest cover has been removed for cropland. Some less-disturbed bottomland forest and cypress-gum swamp habitats still remain. Several large river systems with wide floodplains, the Obion, Forked Deer, Hatchie, Loosahatchie, and Wolf, cross the region. Streams are low-gradient and murky with silt and sand bottoms, and most have been channelized.

The Nonconnah Creek Watershed, located in Shelby and Fayette Counties, Tennessee, has a drainage area of approximately 190 square miles (mi^2). The entire watershed, including portions of Tennessee and Mississippi, drains approximately 283 mi^2. Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from around 2001. Although changes in the land use of the Nonconnah Creek Watershed have occurred since 2001 as a result of rapid development, this is the most current land use data available. Land use in the Nonconnah Creek Watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the Tennessee portion of the Nonconnah Creek Watershed is urban (64.0%) followed by agriculture (17.4%). Details of land use distribution of impaired subwatersheds in the Nonconnah Creek Watershed are presented in Appendix A.

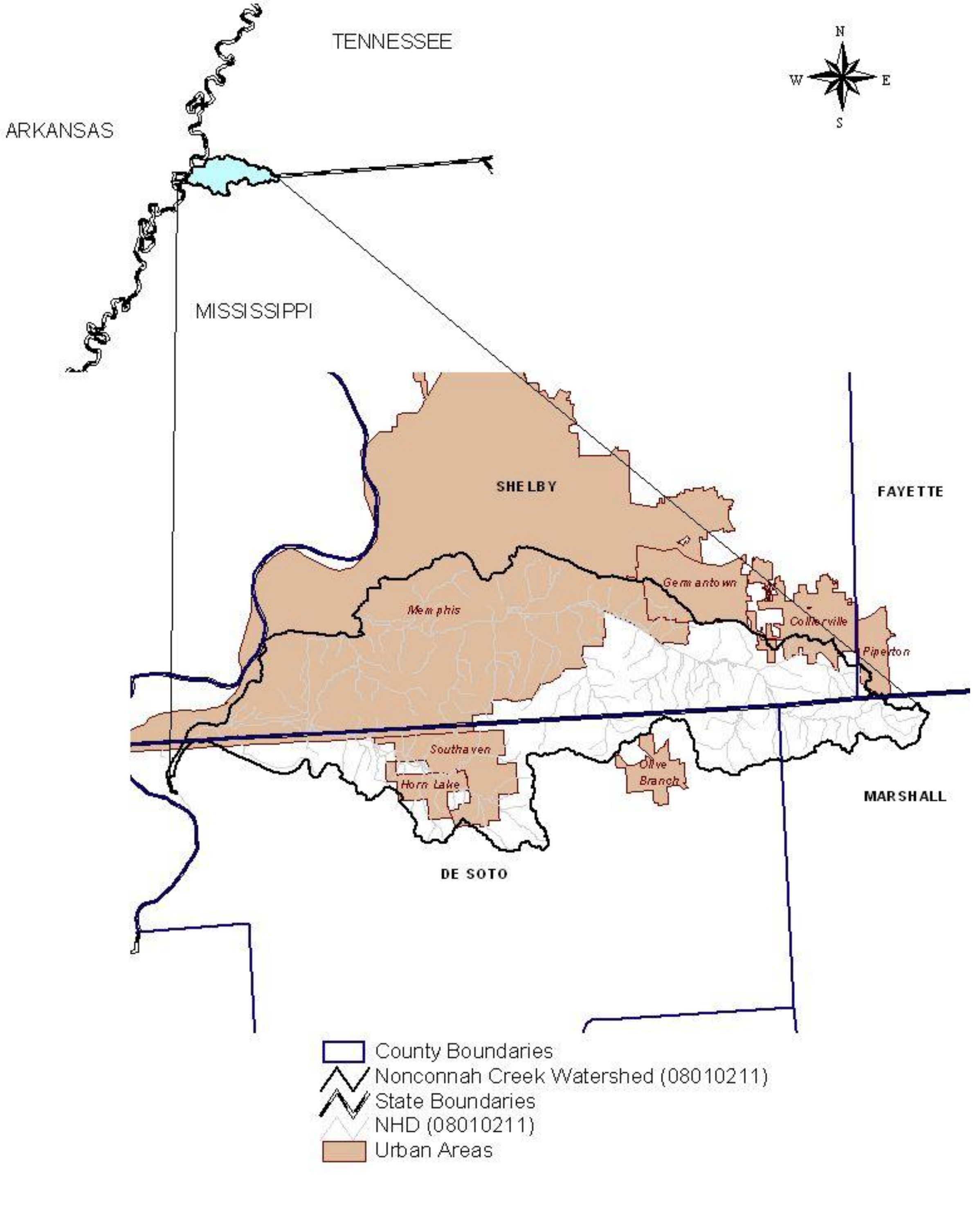

Figure 1 Location of Nonconnah Creek Watershed

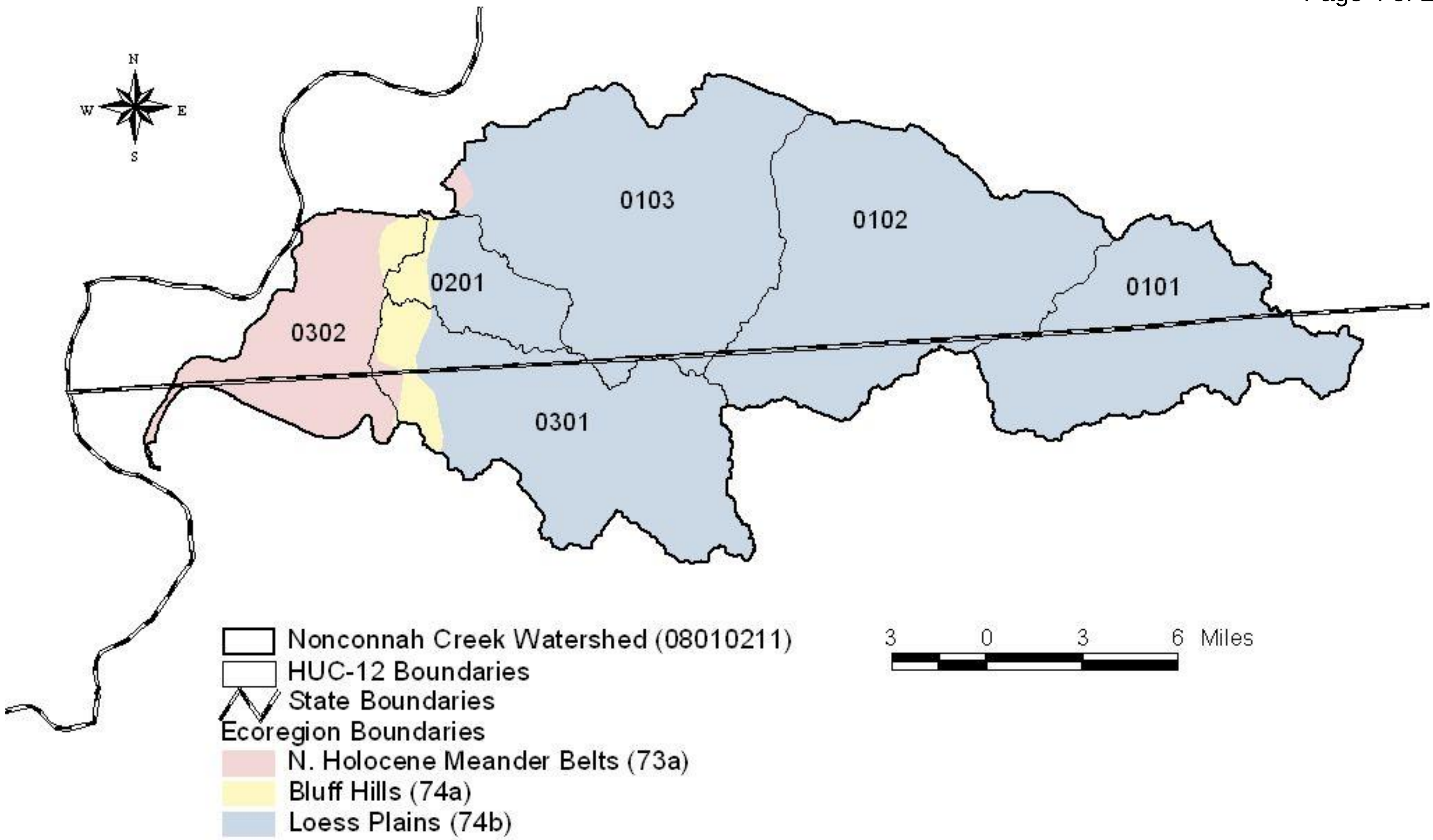

Figure 2. Level IV Ecoregions in the Nonconnah Creek Watershed.

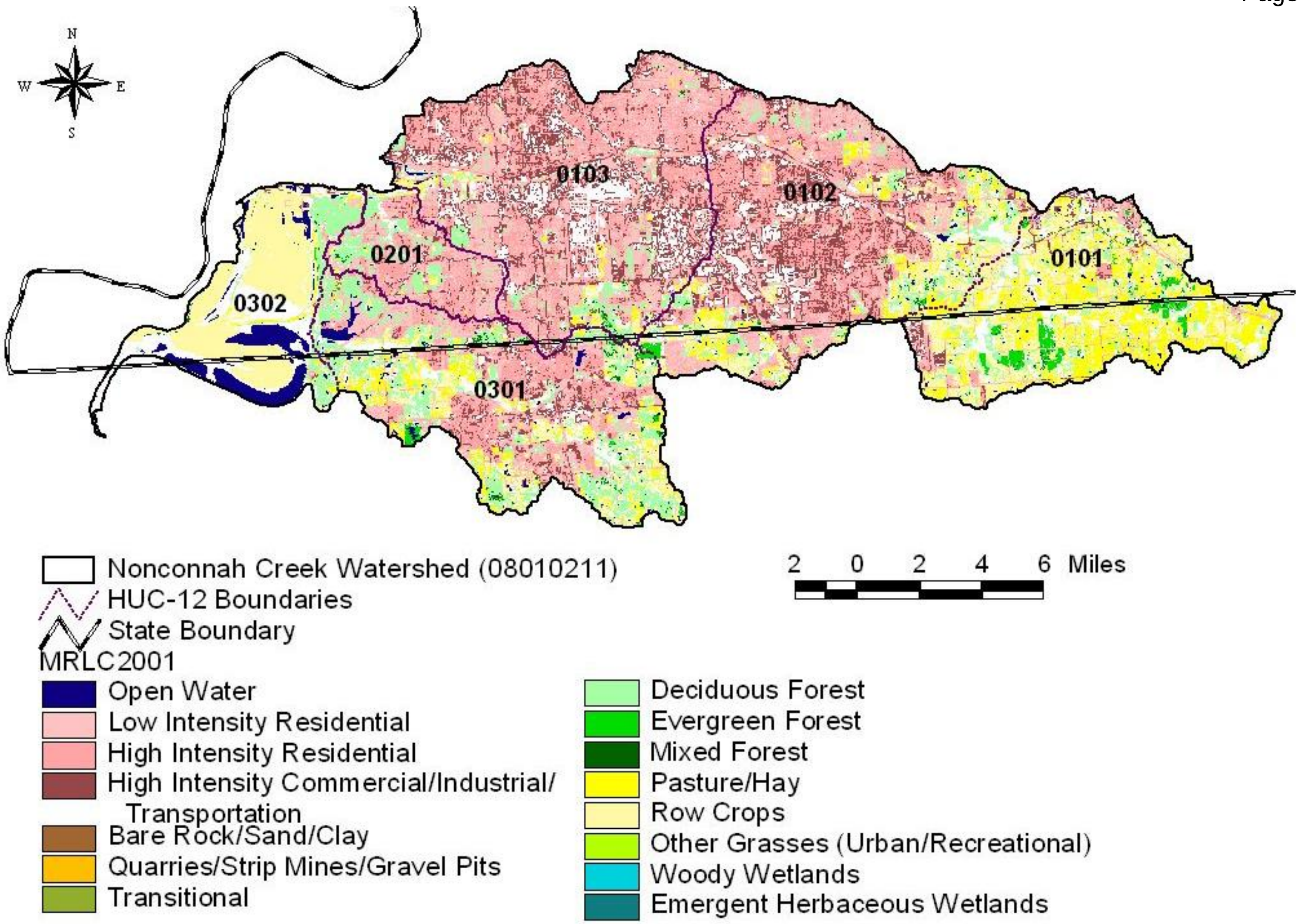

Figure 3 Nonconnah Creek Watershed Land Use Distribution

Table 1. MRLC Land Use Distribution – Nonconnah Creek Watershed (08010211)

Land use	Nonconnah Creek Watershed (TN & MS)		Nonconnah Creek Watershed (TN only)	
	[acres]	[%]	[acres]	[%]
Open Water	3,880	2.2	2,224	1.8
Developed Open Space	34,290	19.2	26,498	21.2
Low Intensity Development	31,843	17.8	25,847	20.7
Medium Intensity Development	20,773	11.6	18,035	14.4
High Intensity Development	10,489	5.9	9,659	7.7
Barren Land (Rock/Sand/Clay)	47	0.0	44	0.0
Deciduous Forest	17,494	9.8	10,301	8.2
Evergreen Forest	2,016	1.1	491	0.4
Mixed Forest	1,150	0.6	652	0.5
Shrub/Scrub	7,472	4.2	2,947	2.4
Grassland/Herbaceous	263	0.1	172	0.1
Pasture/Hay	14,961	8.4	6,186	4.9
Cultivated Crops	24,383	13.6	15,647	12.5
Woody Wetlands	9,417	5.3	6,297	5.0
Emergent Herbaceous Wetlands	218	0.1	138	0.1
Subtotal – Urban	97,395	54.5	80,039	64.0
Subtotal – Agriculture	39,344	22.0	21,833	17.4
Subtotal – Forest	41,957	23.5	23,266	18.6
Total	178,696	100.0	125,138	100.0

Note: A spreadsheet was used for this calculation and values are approximate due to rounding.

3.0 PROBLEM DEFINITION

The State of Tennessee's 2012 303(d) list (TDEC, 2014), http://www.tn.gov/environment/water/docs/wpc/2012-final-303d-list.pdf was approved by USEPA in January 2014. The list identified several waterbodies in the Nonconnah Creek Watershed as not supporting designated use classifications due, in part, to arsenic. An excerpt from the Final 2012 303(d) list is presented in Table 2. Waterbodies included on the 303(d) list are shown in Figure 4.

Table 2 Final 2012 303(d) List – Nonconnah Creek Watershed

Waterbody ID	Impacted Waterbody	County	Miles/Acres Impaired	Cause	Pollutant Source
TN08010211001 – 0100	Horn Lake Cutoff	Shelby	16.4	Low dissolved oxygen Total Phosphorus Loss of biological integrity due to siltation Arsenic Escherichia coli	Discharges from MS4 area
TN08010211001 – 2000	Horn Lake Creek (from Horn Lake Cutoff to Mississippi state line)	Shelby	5.2	Low dissolved oxygen Loss of biological integrity due to siltation Arsenic Escherichia coli	Sources Outside of State Discharges from MS4 area
TN08010211007 – 1000	Cypress Creek	Shelby	18.2	Low dissolved oxygen Total Phosphorus Arsenic Escherichia coli	Discharges from MS4 area

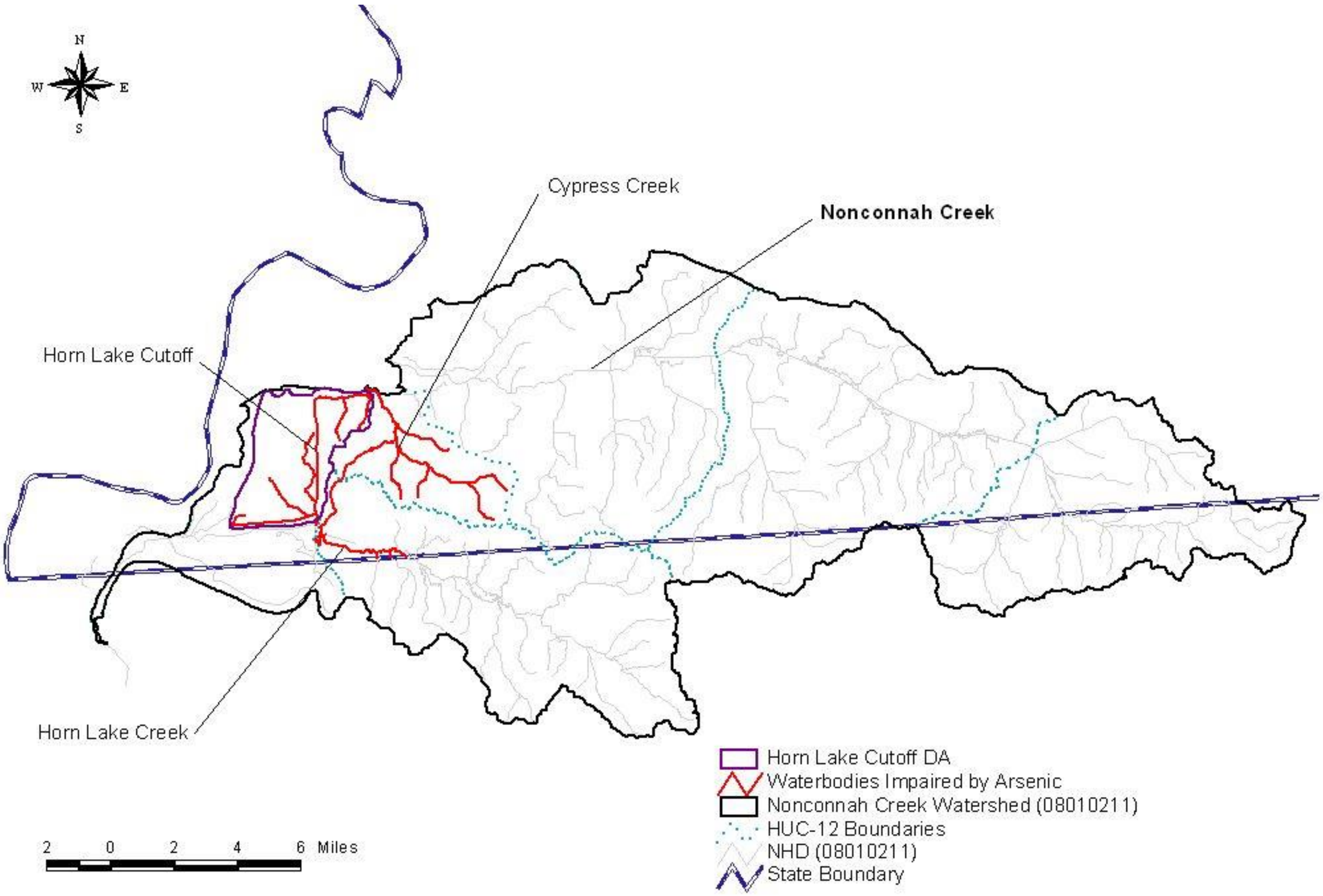

Figure 4 Nonconnah Creek Watershed Arsenic-Impaired Segments

The designated use classifications for the Nonconnah Creek and their tributaries include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Assessment information for waterbodies impaired due to arsenic in the Nonconnah Creek Watershed is available in the EPA/TDEC Assessment Database (ADB) and is referenced to the waterbody IDs in Table 2. ADB information may be accessed at: http://tnmap.tn.gov/wpc/ .

The major concerns regarding metal contamination are toxicity to fish and aquatic life, plus the danger it poses to people who come in contact with the water or eat fish from the contaminated waterbody. The precipitation of metals in streams can also affect habitat. Occasionally, metals are elevated in streams and rivers due to natural conditions. However, it is relatively rare for waterbodies to violate criteria for metals simply based on natural conditions.

3.1 Effects of Arsenic

Arsenic is a ubiquitous, naturally occurring element. Arsenic may exist in both an organic and inorganic form, either in the trivalent (arsenite) or pentavalent (arsenate) oxidation state. Arsenite tends to predominate under reducing conditions and arsenate tends to predominate under oxidizing conditions. Trivalent forms of arsenic (inorganic and organic) are more toxic to humans and aquatic organisms and are usually only present under anaerobic conditions (ODEQ, 2001). Webb (1966) found that arsenite is approximately 60 times more toxic to humans than arsenate. With few exceptions, inorganic arsenic is more toxic than organic arsenic.

Some arsenic species have an affinity for clay mineral surfaces and organic matter, and this can affect their environmental behavior. Methylation and demethylation reactions are also important transformations controlling the mobilization and subsequent distribution of arsenicals. Transport and partitioning of arsenic in water depends on the chemical form of the arsenic and on interactions with other materials present. Arsenic may be adsorbed from water on to clays, iron oxides, aluminum hydroxides, manganese compounds, and organic material. (WHO, 2001)

Arsenic compounds cause acute and chronic effects in individuals, populations and communities at concentrations ranging from a few micrograms per liter, depending on species, time of exposure, and end-points measured. These effects include lethality, inhibition of growth, photosynthesis and reproduction, and behavioral effects. (WHO, 2001) Arsenic-contaminated environments are characterized by limited species abundance and diversity. If levels of arsenate are high enough, only species that exhibit resistance may be present. (Brooks, 2000)

Arsenic has long been known because of its acute and long-term toxicity. The EPA has classified arsenic as a known carcinogen. Sources of human exposure to arsenic compounds may include air, soil, water and food. Dietary sources may include dairy products, meat, poultry and fish, fruits and vegetable and grain products. However, the greatest potential hazard is in the consumption of water containing high concentrations of inorganic arsenite (Webb, 1966).

Arsenic has effects on widely different organ systems in the body. It has produced serious effects on humans after both oral and inhalation exposure, it has many end-points, and exposure is widespread all over the world. Ingestion of large doses of arsenic may lead to acute symptoms within 30-60 min, but the effects may be delayed when the arsenic is taken with food. Acute gastrointestinal syndrome is the most common presentation of acute arsenic poisoning. (WHO, 2001)

Incidents of continuous or repeated oral exposure to arsenic have been described. Symptoms, mainly from the gastrointestinal tract and skin, were observed among 220 patients studied among 447 who had been exposed to arsenic in soy sauce at a level of 100 mg/L for 2-3 weeks; the estimated daily dose of arsenic was 3 mg. In a mass poisoning in Japan, where 12,000 infants were fed with milk powder inadvertently contaminated with arsenic at a level of 15-24 mg/kg, leading to an estimated daily dose of 1.3-3.6 mg for a period of varying duration, 130 of the infants died. Chronic skin effects of arsenic, including pigmentation changes, hyperkeratosis, and skin cancer, from medicinal use, but also from drinking-water, were reported as early as the 19th century. A large number of case series on arsenical skin cancer after exposure via drinking water were published from Argentina, Chile, Mexico, and Taiwan in the early 1900s. (WHO, 2001)

A peculiarity of arsenic carcinogenicity is that the information mainly comes from experience with exposed humans; it has been unusually difficult to find any animal models (WHO, 2001).

4.0 TARGET IDENTIFICATION

Numeric water quality criteria for arsenic for each designated use, as stated in the *State of Tennessee Water Quality Standards*, are summarized in Table 3. Where multiple criteria are applicable to a specific waterbody, the most protective criterion will be used.

Table 3 Numeric Metals Criteria for Applicable Designated Use Classification

Metal (Total Recoverable)	Designated Use Classification	Criteria [µg/l]
Arsenic	Recreation (Organisms Only)	10
Arsenic (III)	Fish & Aquatic Life (CCC)	150
Arsenic (III)	Fish & Aquatic Life (CMC)	340

In accordance with the guidance in *Technical Support Document For Water Quality-based Toxics Control* (USEPA, 1991b), fish & aquatic life criteria are interpreted to mean that the 1-hour average exposure should not exceed the Criterion Maximum Concentration (CMC) and the 4-day average exposure should not exceed the Criterion Continuous Concentration (CCC). Excursions of CMCs & CCCs should not exceed a frequency of once every three years.

As explained in Section 3.1, arsenic can exist in several forms. Arsenic(III) is a subset of Total Arsenic. Since the recreation criteria is expressed as total arsenic and is more stringent than the fish & aquatic life criteria, the recreation criteria is more conservative than the fish & aquatic life criteria. Therefore, the target criteria for arsenic will be 10 µg/L.

5.0 WATER QUALITY ASSESSMENT AND DIFFERENCE FROM TARGET

Water quality monitoring of the Nonconnah Creek Watershed was conducted by Division of Water Resources (DWR) personnel from the Memphis Environmental Field Office (EFO) during the period from 9/9/98 through 6/7/11. Several monitoring stations were located on or near impaired segments in the Nonconnah Creek Watershed (see Figure 5).

- HUC-12 08010211_0201:
  - *CCSOU001.1SH – Cypress Creek, at Weaver Rd.*
  - *CCSOU004.0SH – Cypress Creek, east of Horn Lake Rd. in the adjacent park*
- HUC-12 08010211_0301:
  - HLAKE004.0SH – Horn Lake Creek, at Weaver Rd.
- HUC-12 08010211_0302:
  - HLAKE000.0SH – Horn Lake Creek, at Lower Levee Rd., lower section of creek

The arsenic data collected at each monitoring site (ref: Appendix B) in the Nonconnah Creek Watershed are tabulated and compared to the target in Table 4.

Table 4. Summary of TDEC Water Quality Monitoring Data

Monitoring Station	Date Range	Data Pts.	Min. (μg/L)	Avg. (μg/L)	Max. (μg/L)	No. Exceed. Target
CCSOU001.1SH	2001 – 2011	27	1.8	9.12	29	7
CCSOU004.0SH	2001 – 2011	26	2.1	13.88	63	14
HLAKE000.0SH	1999 – 2011	27	ND	5.95	15	3
HLAKE004.0SH	1998 – 2011	27	1.0	7.98	31	8

No monitoring data was available for Horn Lake Cutoff.

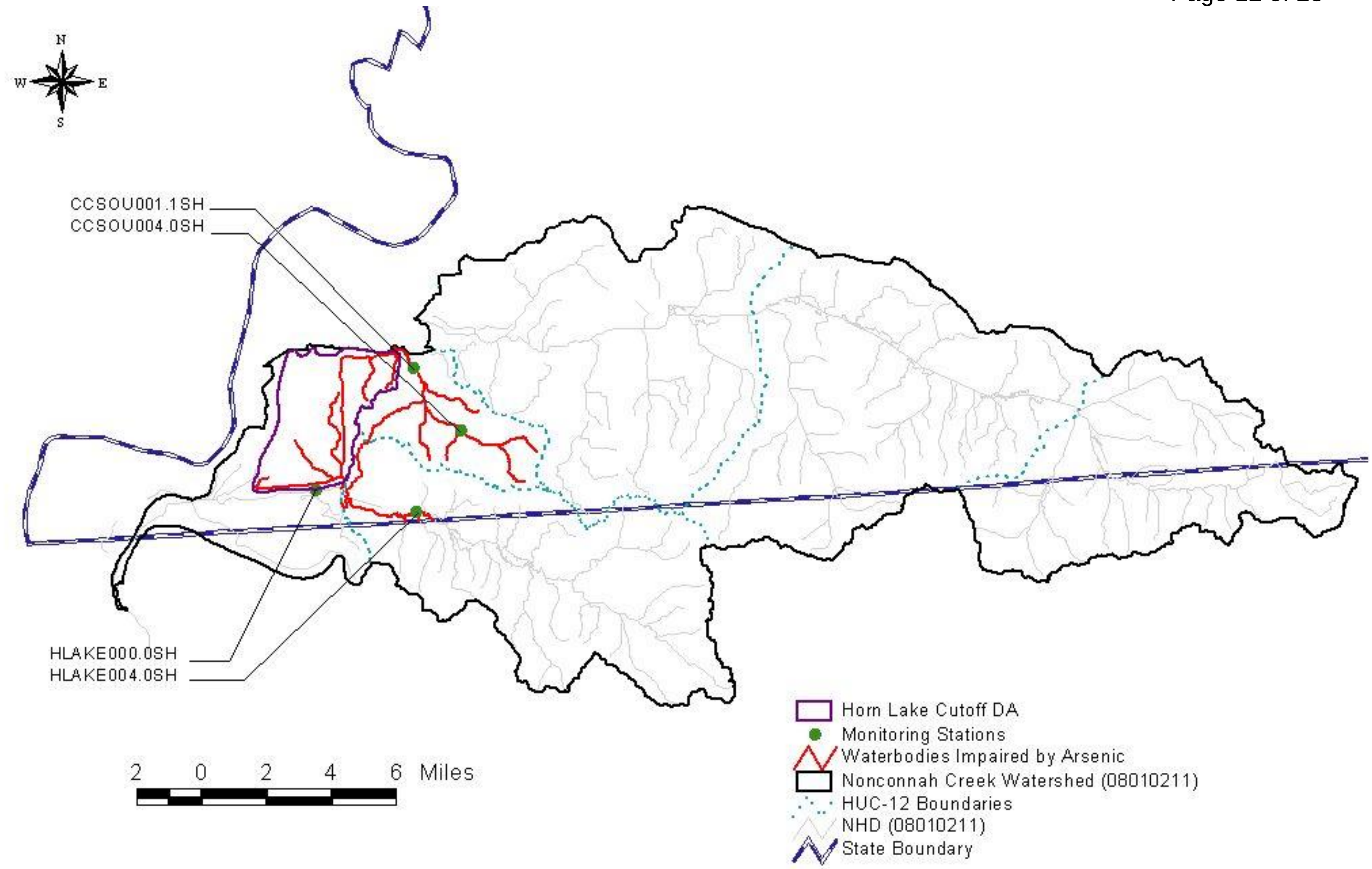

Figure 5 Nonconnah Creek Watershed Monitoring Stations

6.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of individual sources, or source categories, of arsenic in the watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either point or non-point sources. A point source can be defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Non-point sources include all other sources of pollution.

6.1 Point Sources

6.1.1 NPDES Regulated Individual and Tenessee Multi-Sector Permits

Stormwater discharges from regulated industrial facilities are authorized under NPDES Permit No. TNR050000, Tennessee Stormwater Multi-Sector General Permit (TMSP) for Industrial Activities (TDEC, 2009). Operators of point source discharges of storm water associated with industrial activity, that discharge into waters of the State of Tennessee, represented by multiple industry sectors identified in the permit, are authorized to discharge storm water runoff in accordance with storm water pollution prevention plan requirements, effluent limitations, and monitoring and reporting requirements, from the subject facilities to waters of the State of Tennessee. As of December 1, 2013, there is one facility located in the Horn Lake Creek subwatershed with active coverage under the TMSP in sector K-1, which requires monitoring for arsenic. This facility (Excel TSD of Tennessee, LLC) has been conducting monitoring as required in their permit and there have been no exceedances of their effluent limit. There are no facilities located in the Cypress Creek subwatershed with active coverage under the TMSP. There are no facilities covered under an individual stormwater permit requiring arsenic monitoring located in the Horn Lake Creek and Cypress Creek subwatersheds.

6.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

MS4s may discharge stormwater runoff to waterbodies in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. These systems convey urban runoff from construction sites, roads, municipal operations such as garages, schools, storage facilities, golf courses, etc.; and residential, commercial, and industrial properties. Phase I of the EPA storm water program requires large and medium MS4s to obtain NPDES storm water permits. Large and medium MS4s are those located in incorporated places or counties serving populations greater than 100,000 people. The only Phase I MS4 entity in the Nonconnah Creek Watershed is the City of Memphis (TNS068276).

As of March 2003, regulated small MS4s in Tennessee must also obtain NPDES permits in accordance with the Phase II storm water program. A small MS4 is designated as *regulated* if: a) it is located within the boundaries of a defined urbanized area that has a residential population of at least 50,000 people and an overall population density of 1,000 people per square mile; b) it is located outside of an urbanized area but within a jurisdiction with a population of at least 10,000 people, a population density of 1,000 people per square mile, and has the potential to cause an adverse impact on water quality; or c) it is located outside of an urbanized area but contributes substantially to the pollutant loadings of a physically interconnected MS4 regulated by the NPDES storm water program. Most regulated small MS4s in Tennessee obtain coverage under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2010). At present, there are three (3) permitted Phase II MS4s in the Nonconnah Creek Watershed: the cities of Collierville and Germantown, and Shelby County. Shelby County is the only Phase II MS4 which might contain portions of the Horn Creek and Cypress Creek subwatersheds.

The Tennessee Department of Transportation (TDOT) has been issued an individual MS4 permit (TNS077585) that authorizes discharges of storm water runoff from State road and interstate highway rights-of-way that TDOT owns or maintains, discharges of storm water runoff from TDOT owned or operated facilities, and certain specified non-storm water discharges. This permit covers all eligible TDOT discharges statewide, including those located outside of urbanized areas.

The TDOT MS4 will not be considered a potential source because: (1) The area covered by the permit is less than 0.24% of the overall impaired watershed drainage areas; and (2) Studies by various government agencies of stormwater runoff from state highways indicates negligible contribution of arsenic. (For more detail, see Appendix G.)

For information regarding storm water permitting in Tennessee, see the TDEC website:

http://www.tn.gov/environment/water/water-quality_storm-water.shtml

In addition to traffic density, the pavement condition and compactation are significant in determining the traffic impact on pollution accumulation. Streets paved entirely with asphalt have total solids loadings about 80% higher than all concrete streets. Streets whose conditions were rated "fair-to-poor" were found to have total solids loadings 2.5 times greater than those rated "good-to-excellent." (Novotny, 1981)

In the Final 2012 303(d) List (ref.: Table 2), discharges from MS4 areas was identified as the source of arsenic in several impaired waterbodies in the watershed. This TMDL will consider discharges from MS4 areas as one of the primary sources of metals contamination in the Nonconnah Creek watershed.

6.2 Non-point Sources

Arsenic is the main constituent of more than 200 mineral species (WHO, 2001). In nature, arsenic-bearing minerals undergo oxidation and release arsenic to water. Nationally, approximately 21 percent of stream and river samples collected by the USGS in a 1969 study had arsenic concentrations above 10 μ/L (Welch et al 1988). No information was given as to the suspected source of surface water arsenic, other than to note that it is "unusual to find high arsenic concentrations in river water without a significant contribution of arsenic from geothermal water or mineralized areas". Edwards (1994) reported that a random survey of raw drinking water sources in the United States resulted in an average arsenic concentration of 4 μg/L.

Historic use of arsenic-containing pesticides is suspected as a source that may be contributing to the elevated arsenic levels. In 1983, arsenical pesticides were one of the largest classes of biocontrol agents in the USA (WHO, 2001). Only very limited quantities of arsenic-containing pesticides are still manufactured and used under strict limitations in the U.S. However, arsenic has proven to be a problem in suburban areas where subdivisions have crept out on to former agricultural land where pesticides containing lead arsenate were applied (Hodel, 2002). Litter from poultry fed organic arsenic additives is another possible anthropogenic source.

Approximately 90 percent of industrial arsenic in the U.S. is currently used as a wood preservative, but arsenic is also used in paints, dyes, metals, drugs, soaps, and semi-conductors. (USEPA, 2011) Arsenic has been used in manufactured wood products, like particleboard and treated lumber, to prevent rot and provide weather resistance. A study of anthropogenic sources of arsenic and copper in a small (0.91 mi^2), densely populated suburban watershed in Virginia (Rice, 2002) found that over 50% of the arsenic in a small (< 30 ac.) recreational lake was attributable to pressure treated lumber and that urbanization of the watershed was a major cause of increasing arsenic concentrations in the lake sediments. Atmospheric deposition was found to be an insignificant source (< 3%) of arsenic to the lake.

Arsenic associated with unregulated urban runoff can come from erosion of natural deposits. (USEPA, 2011) A study under EPA's National Urban Runoff Project indicated that arsenic concentrations in stormwater runoff ranged from 1 to 51 μg/L in different areas of the United States.

7.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\text{TMDL} = \Sigma\ \text{WLAs} + \Sigma\ \text{LAs} + \text{MOS}$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or other appropriate measure.

7.1 Expression of TMDLs, WLAs, & LAs

In this document, the TMDL for arsenic is a daily load expressed as a function of mean daily flow (daily loading function). WLAs & LAs are also expressed as daily loading functions in lbs/day/acre. In order to facilitate implementation, corresponding percent load reduction goals (PLRGs) to decrease arsenic loads to TMDL target levels are also expressed.

7.2 Critical Conditions and Seasonal Variation

The critical condition for precipitation-induced non-point source arsenic loading is usually an extended dry period followed by a rainfall runoff event. During the dry weather, arsenic builds up on the land surface and is washed off by rainfall. This condition is represented in the TMDL analyses.

The flow zone with the most exceedances was determined at each monitoring site using Load Duration Curves as described in Appendix C. A Load Duration Curve (LDC) is a cumulative frequency graph that illustrates existing water quality conditions (as represented by monitoring data) and the portion of the waterbody flow zone represented by these data.

The eleven-year period from January 1, 2001 to December 31, 2011 was used to simulate flow. This 11-year period contained a range of hydrologic conditions that included both low and high streamflows. Seasonal variation is accounted for in the analyses by using the entire period of flow and water quality data available for the impaired waterbodies. In the Nonconnah Creek subwatersheds, water quality data have been collected during most flow ranges. However, no monitoring data was available for Horn Lake Cutoff.

7.3 Margin of Safety

There are two methods for incorporating an MOS in the analysis: a) implicitly incorporate the MOS using conservative modeling assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations.

For development of arsenic TMDLs, an explicit MOS, equal to 10% of the water quality target (ref.: Section 4.0), was utilized for determination of WLAs and LAs.

7.4 Determination of Total Maximum Daily Loads

Daily loading functions were derived for impaired segments in the Nonconnah Creek Watershed using water quality criteria and average daily flow according to the procedure in Appendix C. These TMDL loading functions for impaired segments and subsequent subwatersheds are shown in Table 5.

7.5 Determination of WLAs & LAs

WLAs and LAs were determined according to the procedures in Appendix C. These allocations represent the available loading <u>after application of the explicit MOS</u>. The WLAs and LAs for arsenic in the Nonconnah Creek Watershed are summarized in Table 5.

Table 5. TMDLs, WLAs, and LAs expressed as daily loads for Impaired Waterbodies in the Nonconnah Creek Watershed (HUC 08010211)

HUC-12 Subwatershed (08010211__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	PLRG	WLAs	LAs [b]
						MS4s [a,b]	
			[lbs/day]	[lbs/day]	[%]	[lbs/day/ac]	[lbs/day/ac]
0201	Cypress Creek	TN08010211007 – 1000	$5.39 \times 10^{-2} \times Q$	$5.39 \times 10^{-3} \times Q$	60.0	$5.587 \times 10^{-6} \times Q$	$5.587 \times 10^{-6} \times Q$
0301/0302	Horn Lake Creek	TN08010211001 – 2000	$5.39 \times 10^{-2} \times Q$	$5.39 \times 10^{-3} \times Q$	23.1	$1.303 \times 10^{-6} \times Q$	$1.303 \times 10^{-6} \times Q$
	Horn Lake Cutoff	TN08010211001 – 0100					

Notes: Q = Mean Daily In-stream Flow (cfs).
PLRG = Percent Load Reduction Goal to achieve TMDL.
NR = No reduction required.

a. Applies to any MS4 discharge loading in the subwatershed. Future MS4s will be assigned waste load allocations (WLAs) consistent with load allocations (LAs) assigned to precipitation induced nonpoint sources.

b. WLAs and LAs expressed as a “per acre” load are calculated based on the drainage area at the pour point of the HUC-12 or drainage area.

8.0 IMPLEMENTATION PLAN

Monitoring conducted in 1998 thru 2011 has identified a number of waterbodies in the Nonconnah Creek Watershed as impaired due to arsenic. This condition is primarily the result of discharges from urban areas.

Individual arsenic load reduction goals were calculated for impaired segments to evaluate compliance with the target concentrations according to the procedure in Appendix C. The load reductions were calculated at each monitoring site within the drainage area for which monitoring data was available. The load reductions for the Nonconnah Creek Watershed are also summarized in Table 5. Required load reductions will be implemented in several steps to reduce the concentration of arsenic.

TDEC recommends water quality testing for Horn Lake Cutoff to confirm the status of segment 001-0100 as impaired by arsenic. No monitoring data was available for this waterbody. If Horn Lake Cutoff is no longer impaired by arsenic, then it should be de-listed for arsenic.

8.1 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For present and future regulated discharges from municipal separate storm sewer systems (MS4s), WLAs are and will be implemented through Phase I & II MS4 permits. These permits will require the development and implementation of a Storm Water Management Program (SWMP) that will reduce the discharge of pollutants to the "maximum extent practicable" and not cause violations of State water quality standards. Both the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2010) and the individual MS4 permits (TDOT - TNS077585 and Memphis – TNS068276) require SWMPs to include minimum control measures. The permits also contain requirements regarding control of discharges of pollutants of concern into impaired waterbodies, implementation of provisions of approved TMDLs, and descriptions of methods to evaluate whether storm water controls are adequate to meet the requirements of approved TMDLs.

For guidance on the six minimum control measures for MS4s regulated under Phase I or Phase II, a series of fact sheets are available at: http://cfpub1.epa.gov/npdes/stormwater/swfinal.cfm .

For further information on Tennessee's *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems*, see:
http://www.state.tn.us/environment/water/docs/wpc/tns000000_MS4_phase_ii_2010.pdf.

In order to evaluate SWMP effectiveness and demonstrate compliance with specified WLAs, MS4s must develop and implement appropriate monitoring programs.

Each MS4 having a waterbody listed as impaired due to metals within their jurisdiction must conduct water quality monitoring for metals. Monitoring must include sampling at least one location on the most impaired stream segment located within the MS4 jurisdiction. (The most impaired segment should be the segment with the most exceedances based on the data included in Appendix B of the TMDL and summarized in Table 4.) Whenever possible, testing should be done at existing ambient monitoring stations to allow for continuity. Sampling must be conducted on at least a quarterly basis and parameters must include flow and total arsenic. Sampling should be conducted following implementation of one or more BMPs.

An effective monitoring program could also include:

- Effluent monitoring at selected outfalls that are representative of particular land uses or geographical areas that contribute to pollutant loading before and after implementation of pollutant control measures.

- Analytical monitoring of pollutants of concern (e.g., monthly) in receiving waterbodies, both upstream and downstream of MS4 discharges, over an extended period of time. In addition, intensive collection of pollutant monitoring data during the recreation season (June – September).

When applicable, the appropriate Division of Water Resources Environmental Field Office should be consulted for assistance in the determination of monitoring strategies, locations, frequency, and methods within 12 months after the approval date of TMDLs or initial designation as a regulated MS4. Details of the monitoring plans and monitoring data should be included in annual reports required by MS4 permits.

8.2 Nonpoint Sources

The Tennessee Department of Environment & Conservation has no direct regulatory authority over most nonpoint source (NPS) discharges. Reductions of arsenic loading from nonpoint sources will be achieved using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired waters. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. There are links to a number of publications and information resources on EPA's Nonpoint Source Pollution web page (http://water.epa.gov/polwaste/nps/index.cfm) related to the implementation and evaluation of nonpoint source pollution control measures.

Management measures to reduce arsenic loading from urban nonpoint sources are similar to those recommended for MS4s (Sect. 8.1). Specific categories of urban nonpoint sources include stormwater and illicit discharges.

> Stormwater: BMPs are typically designed to remove sediment and other pollutants. Metals in stormwater runoff are, however, often attached to particulate matter. Therefore, treatment systems that remove sediment may also provide reductions in metals concentrations.
>
> Illicit discharges: Removal of illicit discharges to storm sewer systems may be an effective means of reducing metals loading to receiving waters (ENSR, 2005). These include intentional illegal connections from commercial or residential buildings.

Two additional urban nonpoint source resource documents provided by EPA are:

National Management Measures to Control Nonpoint Source Pollution from Urban Areas (http://www.epa.gov/owow/nps/urbanmm/index.html) helps citizens and municipalities in urban areas protect bodies of water from polluted runoff that can result from everyday activities. The scientifically sound techniques techniques it presents are among the best practices known today. The guidance will also help states to implement their nonpoint source control programs and municipalities to implement their Phase II Storm Water Permit Programs (Publication Number EPA 841-B-05-004, November 2005).

The Use of Best Management Practices (BMPs) in Urban Watersheds (http://nepis.epa.gov/Adobe/PDF/2000D1LM.pdf) is a comprehensive literature review on commonly used urban watershed Best Management Practices (BMPs) that heretofore was not consolidated. The purpose of this document is to serve as an information source to individuals and agencies/municipalities/watershed management groups/etc. on the existing state of BMPs in urban stormwater management (Publication Number EPA/600/R-04/184, September 2004).

9.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed Arsenic TMDL for the Nonconnah Creek Watershed was placed on Public Notice for a 35-day period and comments solicited. Steps that were taken in this regard include:

1) Notice of the proposed TMDL was posted on the Tennessee Department of Environment and Conservation website. The announcement invited public and stakeholder comment and provided a link to a downloadable version of the TMDL document.

2) Notice of the availability of the proposed TMDL (similar to the website announcement) was included in one of the NPDES permit Public Notice mailings which is sent to approximately 90 interested persons or groups who have requested this information.

3) Letters were sent to all facilities located in arsenic-impaired subwatersheds or drainage areas in the Nonconnah Creek Watershed, with coverage under the TMSP general permit, advising them of the proposed TMDLs and their availability on the TDEC website. The letters also stated that a copy of the draft TMDL document would be provided on request. A letter was sent to the following facilities:

   Excel TSD of Tennessee, LLC (TNR050717)

4) A draft copy of the proposed TMDL was sent to those MS4s that are wholly or partially located in arsenic-impaired subwatersheds. A draft copy was sent to the following entities:

   City of Memphis MS4, Tennessee (TNS068276)
   Shelby County (TNS075663)
   Tennessee Dept. of Transportation (TNS077585)

5) A letter was sent to identified water quality partners in the Nonconnah Creek Watershed advising them of the proposed arsenic TMDLs, stating the document's availability on the TDEC website, and inviting comments. These partners included:

   Natural Resources Conservation Service
   Tennessee Department of Agriculture
   Tennessee Water Sentinels
   United States Army Corps of Engineers
   United States Fish and Wildlife Service
   United States Geological Survey
   The Nature Conservancy

10.0 FURTHER INFORMATION

Further information concerning Tennessee's TMDL program can be found on the Internet at the Tennessee Department of Environment and Conservation website:

http://www.state.tn.us/environment/water/water-quality_total-daily-maximum-loads.shtml

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Resources staff:

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APPENDIX A

Land Use Distribution in the Nonconnah Creek Watershed

Table A-1 2001 MRLC Land Use Distribution of Impaired HUC-12s & Drainage Areas

Land Use	Impaired Subwatershed (08010211____)					
	0201 (Cypress Creek)		0301 (Horn Lake headwaters)		0302 (Horn Lake mouth & Horn Lake Cutoff)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Open Water	80.8	0.93	566.7	1.64	2,367.0	12.93
Developed Open Space	2,978.1	34.27	8,133.7	23.54	1,096.6	5.99
Low Intensity Development	1,943.1	22.36	6,271.3	18.15	314.9	1.72
Medium Intensity Development	728.2	8.38	2,691.7	7.79	109.8	0.60
High Intensity Development	362.4	4.17	922.6	2.67	23.8	0.13
Bare Rock	12.2	0.14	20.7	0.06	27.5	0.15
Deciduous Forest	1,874.5	21.57	6,146.9	17.79	2,903.4	15.86
Evergreen Forest	4.3	0.05	411.2	1.19	20.1	0.11
Mixed Forest	29.5	0.34	342.1	0.99	102.5	0.56
Shrub/Scrub	139.0	1.60	2,353.0	6.81	519.9	2.84
Grassland/Herbaceous	0.0	0.00	20.7	0.06	106.2	0.58
Pasture/Hay	114.7	1.32	2,494.7	7.22	596.8	3.26
Row Crops	218.1	2.51	2,926.6	8.47	6,758.8	36.92
Woody Wetlands	195.5	2.25	1,205.9	3.49	3,286.0	17.95
Emergent Herbaceous Wetlands	9.6	0.11	48.4	0.14	71.4	0.39
Subtotal - Forest	2,264.7	26.06	10,548.9	30.53	7,037.1	38.44
Subtotal - Agriculture	332.8	3.83	5,421.3	15.69	7,355.6	40.18
Subtotal – Urban	6,011.9	69.18	18,019.2	52.15	1,545.1	8.44
Total	**8,690.2**	**100.00**	**34,556.1**	**100.00**	**18,304.8**	**100.00**

APPENDIX B

TDEC Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for arsenic in the Nonconnah Creek Watershed. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded by TDEC at these stations are tabulated in Table B-1.

Table B-1. TDEC Water Quality Monitoring Data

Monitoring Station	Date	Arsenic [μ/L]
CCSOU001.1SH	1/31/01	5
	2/28/01	4
	3/28/01	3
	4/26/01	9
	5/23/01	**17**
	6/19/01	**24**
	7/25/01	**12**
	8/29/01	**15**
	10/2/01	8
	10/30/01	**10**
	12/5/01	7
	1/16/02	4
	4/24/02	**29**
	8/24/05	**13**
	9/28/05	**10**
	10/26/05	6
	7/14/10	8.8
	8/18/10	**23**
	9/22/10	4
	10/13/10	3.1
	11/17/10	3.3
	12/13/10	7
	1/27/11	1.8
	2/16/11	1.8
	3/8/11	3.8
	4/19/11	7.5
	6/7/11	6.2
CCSOU004.0SH	1/31/01	5
	2/28/01	3
	3/28/01	4
	4/26/01	**12**
	5/23/01	**16**
	6/19/01	**63**

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	Arsenic [μ/L]
CCSOU004.0SH (cont'd)	7/25/01	**15**
	8/29/01	**32**
	10/2/01	**10**
	10/30/01	**16**
	12/5/01	**10**
	1/16/02	6
	4/24/02	**22**
	8/24/05	**11**
	9/28/05	**18.9**
	10/26/05	**13**
	7/14/10	**11**
	8/18/10	**25**
	11/17/10	5.3
	12/13/10	**10**
	1/27/11	4.2
	2/16/11	2.1
	3/8/11	4.4
	4/19/11	9
	5/17/11	**12**
	6/7/11	**21**
HLAKE000.0SH	4/21/99	0.5
	10/21/99	2
	4/18/00	5
	1/31/01	**11**
	2/28/01	6
	3/28/01	2
	4/26/01	2
	5/23/01	**23**
	6/19/01	5
	7/25/01	**15**
	8/29/01	6
	10/2/01	7
	10/30/01	**10**
	12/5/01	7
	1/16/02	6
	4/24/02	8
	7/14/10	**10**

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	Arsenic [μ/L]
HLAKE000.0SH (cont'd)	8/18/10	4.5
	9/22/10	3.7
	10/13/10	2.8
	11/17/10	1.5
	12/13/10	5.5
	1/27/11	5.6
	2/16/11	1.7
	3/8/11	2.8
	4/19/11	4.6
	6/7/11	2.4
HLAKE004.0SH	9/9/98	3
	9/9/99	**11**
	1/31/01	**11**
	2/28/01	9
	3/28/01	3
	4/26/01	**17**
	5/23/01	**31**
	6/19/01	5
	7/25/01	**10**
	8/29/01	**13**
	10/2/01	**13**
	10/30/01	**14**
	12/5/01	9
	1/16/02	6
	4/24/02	7
	7/14/10	13
	8/18/10	3.8
	9/22/10	2.4
	10/13/10	3.5
	11/17/10	1
	12/13/10	6.1
	1/27/11	4.9
	2/16/11	1.3
	3/8/11	2.7
	4/19/11	4.6
	5/17/11	6.4
	6/7/11	3.7

APPENDIX C

Load Duration Curve Development
and
Determination of Daily Loading

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), nonpoint source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\text{TMDL} = \Sigma \text{ WLAs} + \Sigma \text{ LAs} + \text{MOS}$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) (http://www.epa.gov/epacfr40/chapt-I.info/chi-toc.htm) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.

Arsenic TMDLs, WLAs, and LAs were developed for impaired subwatersheds and drainage areas in the Nonconnah Creek Watershed using Load Duration Curves (LDCs). Daily Loads for TMDLs, WLAs, and LAs are expressed as a function of daily mean in-stream flow (daily loading function).

C.1 Development of Flow Duration Curves

A flow duration curve is a cumulative frequency graph, constructed from historic flow data at a particular location, that represents the percentage of time a particular flow rate is equaled or exceeded. Flow duration curves are developed for a waterbody from daily discharges of flow over a period of record. In general, there is a higher level of confidence that curves derived from data over a long period of record correctly represent the entire range of flow. The preferred method of flow duration curve computation uses daily mean data from U.S. Geological Survey (USGS) continuous-record stations (http://waterdata.usgs.gov/tn/nwis/sw) located on the waterbody of interest. For ungaged streams, alternative methods must be used to estimate daily mean flow. These include: 1) regression equations (using drainage area as the independent variable) developed from continuous record stations in the same ecoregion; 2) drainage area extrapolation of data from a nearby continuous-record station of similar size and topography; and 3) calculation of daily mean flow using a dynamic computer model, such as the Windows version of Hydrologic Simulation Program - Fortran (WinHSPF).

Flow duration curves for arsenic-impaired waterbodies in the Nonconnah Creek Watershed were derived from WinHSPF hydrologic simulations based on parameters derived from calibration at USGS Station No. 07032200, located on Nonconnah Creek near Germantown, Tennessee (see Appendix D for details of calibration). For example, a flow-duration curve for Cypress Creek at RM 4.0 was constructed for the period from 1/1/02 through 12/31/11 (RM 1.1 corresponds to the location of monitoring station CCSOU004.0SH). This flow duration curve is shown in Figure C-1 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the highest daily mean flow during this period is exceeded 0% of the time and the lowest daily mean flow is equaled or exceeded 100% of the time). Flow duration curves for other impaired waterbodies was derived using a similar procedure.

C.2 Development of Load Duration Curves

When a water quality target concentration is applied to the flow duration curve, the resulting load duration curve (LDC) represents the allowable pollutant loading in a waterbody over the entire range of flow. Pollutant monitoring data, plotted on a LDC, provides a visual depiction of stream water quality over the entire range of flow as well as the frequency and magnitude of any exceedances. Duration curve intervals can be grouped into several broad categories or zones, in order to provide additional insight about conditions and patterns associated with the impairment. For example, the duration curve could be divided into four zones: high flows (exceeded 0-10% of the time), moist conditions (10-40%), median or mid-range flows (40-70%), and low flows (70-100%). Impairments observed in the low flow zone typically indicate the influence of point sources, while those further left on the duration curve (representing zones of higher flow) generally reflect potential nonpoint source contributions (Stiles, 2003).

Load duration curves for specific monitoring locations in the Nonconnah Creek watershed were developed from the flow duration curves developed in Section C.1, arsenic target concentrations, and available water quality monitoring data. Load duration curves were developed using the following procedure (Cypress Creek at RM4.0 is used as an example):

1. A target load duration curve (LDC) was generated for Cypress Creek at RM4.0 by applying the lead target concentration of 10 μ/L to each of the ranked flows used to generate the flow duration curve and plotting the results. The arsenic target maximum load corresponding to each ranked daily mean flow is:

   $(\text{Target Load})_{\text{Cypress Creek}} = (10\ \mu/\text{L}) \times (Q) \times (\text{UCF})$

   where: Target Load = TMDL (lbs/day)
   Q = daily instream mean flow
   UCF = the required unit conversion factor
   $= 5.3944\text{x}10^{-3}$ (lb-sec-L)/(μg-day-ft^3)

   TMDL = ($5.39\text{x}10^{-2}$) x (Q) lbs/day

2. Daily loads were calculated for each of the water quality samples collected at monitoring station CCSOU004.0SH (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. CCSOU004.0SH was selected for LDC analysis because it was a monitoring station with arsenic concentration data available over a ten year period and exceedances in multiple flow regimes.

   Note: *In order to be consistent for all analyses, the derived daily mean flow was used to compute sampling data loads, even if measured ("instantaneous") flow data was available for some sampling dates.*

   Example – 5/17/11 sampling event:
   Modeled Flow = 0.333 cfs
   Concentration = 12 μg/L
   Daily Load = 2.16×10^{-2} lbs arsenic/day

3. Using the flow duration curves developed in C.1, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event. Each sample load was then plotted on the load duration curves developed in Step 1 according to the PDFE. The resulting arsenic load duration curve is shown in Figure C-2.

Example – 5/17/11 sampling event:
Modeled Flow = 0.333 cfs
PDFE = 49.4%

LDCs for other impaired waterbodies were derived in a similar manner and are shown in Figures C-3 through C-5.

C.3 Development of WLAs, LAs, and MOS

As previously discussed, a TMDL can be expressed as the sum of all point source loads (WLAs), nonpoint source loads (LAs), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

For Arsenic TMDLs in the Nonconnah Creek watershed, the only applicable WLA and LA terms are:

- $[WLA]_{MS4}$ = the allowable metal load for discharges from MS4s. Loading from MS4s is the results of buildup/wash-off processes associated with storm events.
- $[LA]_{SW}$ = the allowable metal loading from nonpoint sources indirectly going to surface waters from all land use areas (except areas covered by an MS4 permit) as a result of the buildup/wash-off processes associated with storm events (i.e., precipitation induced).

Thus, the expression relating TMDLs to precipitation-based point and nonpoint sources is:

$$TMDL - MOS = [\Sigma WLA]_{MS4} + [\Sigma LA]_{SW}$$

WLAs for MS4s and LAs for precipitation-based nonpoint sources are equal on a per unit area basis and may be expressed as the daily allowable load per unit area (acre) resulting from a decrease in in-stream concentrations to TMDL target values minus MOS:

WLA_{MS4} = LA_{SW} = {TMDL – MOS} / DA

Where: DA = waterbody drainage area (acres)

As stated in Section 7.3, an explicit MOS, equal to 10% of the water quality targets (ref.: Section 4.0), was utilized for determination of the percent load reductions necessary to achieve the WLAs and LAs.

Sample Instantaneous Maximum for Arsenic
Target – MOS = (10 μg/L) – (1 μg/L) = 9 μg/L

C.4 Daily Load Calculations

Each of the terms in the equation above can be derived sequentially:

TMDL = (Target Concentration) x (Q) x (UCF)

where: Target Concentration = water quality criterion (μg/l)
Q = daily mean flow (ft^3/sec)
UCF = the required unit conversion factor
= 5.3944×10^{-3} (lb-sec-L)/(μg-day-ft^3)

Using Cypress Creek at mile 4.0 as an example:

$TMDL_{Cypress\ Creek}$ = (10 μg/L) x (Q) x (UCF)

$\mathbf{TMDL_{Cypress\ Creek} = 5.39x10^{-2} \times Q}$ **(lbs/day)**

$MOS_{Cypress\ Creek}$ = TMDL x 0.10

$\mathbf{MOS_{CypressCreek} = 5.39x10^{-3} \times Q}$ **(lbs/day)**

Using the equation in section C.3:

Σ LAs = Σ WLAs = (TMDL – MOS) / DA

$LA_{Cypress\ Creek} = WLA_{Cypress\ Creek} = \{(5.39x10^{-2} \times Q) - (5.39x10^{-3} \times Q)\}$ / (3,041 ac)

$\mathbf{LA_{Cypress\ Creek} = WLA_{CypressCreek} = (1.597 \times 10^{-5}) \times Q}$ **(lbs/day/acre)**

TMDLs, WLAs, & LAs for impaired waterbodies in the Nonconnah Creek Watershed are summarized in Table C-6.

C.5 Calculation of Percent Load Reduction Goals (PLRGs) and Determination of Critical Flow Zones

In order to facilitate implementation, corresponding percent reductions in loading required to decrease existing, in-stream loads to TMDL target levels (percent load reduction goals) were calculated. As a result, critical flow zones were determined and subsequently verified by secondary analyses. The following example is from Cypress Creek at Mile 4.0.

1. For cases where the measured concentration exceeded the target criteria at a particular PDFE, the reduction required to reduce the sample concentration to the target criteria was calculated.

   Example – 5/17/11 sampling event:
   Target Concentration = 10 μg/L
   Measured Concentration = 12 μg/L
   Reduction to Target = 16.7%

2. The LDC for Cypress Creek was analyzed to determine the frequency with which observed daily water quality concentrations exceed the target criteria under four flow conditions (low, mid-range, moist, and high). Observation of the plot illustrates that the exceedances occurred under most flow conditions indicating that the Cypress Creek watershed may be impacted by both point sources and non-point sources.

3. For each flow zone, the mean of the observed percent exceedances of individual concentrations relative to their respective target criteria (at their respective PDFEs) was calculated. Each negative percent exceedance was assumed to be equal to zero.

Date	Sample Conc. (μg/ mL)	Flow (cfs)	Target Criteria (μg/ mL)	Percent Reduction
5/17/11	12	0.333	10	16.7
2/16/11	2.1	0.199	10	0.0
12/13/10	21	0.149	10	52.4
Percent Load Reduction Goal (PLRG) for Mid-Range Flow Conditions (Mean)				**23.0**

4. The PLRGs calculated for each of the flow zones were compared and the PLRG of the greatest magnitude indicates the flow zone for prioritizing implementation actions for Cypress Creek at RM4.0.

   Example – High Flow Zone Percent Load Reduction Goal = 0.0
   Moist Conditions Flow Zone Percent Load Reduction Goal = 2.3
   Mid-Range Flow Zone Percent Load Reduction Goal = 23.0
   Low Flow Zone Percent Load Reduction Goal = 60.0

   Therefore, the flow zone for prioritization of Cypress Creek implementation activities is the Low Flow Zone and subsequently actions targeting predominantly non-point source controls.

Analysis of monitoring data for other arsenic-impaired waterbodies in the Nonconnah Creek Watershed are presented in Tables C-3 thru C-5. A summary of flow zones for prioritization of implementation activities for all arsenic impaired waterbodies in the Nonconnah Creek Watershed is presented in Table C-1.

Table C-1. Summary of Flow Zones and Locations for Prioritization of Implementation Activities for Arsenic Impaired Waterbodies in the Nonconnah Creek Watershed.

Waterbody ID	Critical Zone
Cypress Creek	Low flow (RM4.0)
Horn Lake Creek	High flow (RM4.0)
Horn Lake Cutoff	No critical zone

5. Due to the frequently limited availability of sampling data and subsequent randomness of distribution of samples by flow zone, the determination of the priority flow zone by PLRG calculation often has a high degree of uncertainty. Therefore, secondary analyses were conducted to verify or supplement the determination of the priority flow zones. For each flow zone, the percent of samples that exceed the TMDL target levels was calculated. For Cypress Creek at RM4.0:

Flow Zone	Number of Samples	Samples > Target μg/mL	% > Target μg/mL
High	2	0	0.0
Moist	4	2	50.0
Mid-Range	3	2	66.7
Low	1	1	100.0

The priority flow zone for Cypress Creek implementation activities is confirmed as the low flow zone. If a different flow zone were indicated, both zones would receive equal emphasis for implementation prioritization.

6. Lastly, emphasis (priority) should be placed on recent data versus historical data. If data from multiple watershed cycles is available, analysis of recent data (current cycle) versus the entire period of record, or previous cycles, may identify different priority areas for implementation. The following example is from Cypress Creek at RM4.0.

Zone	Period of Record (2001-2011)			Most Recent (2010-2011)		
	# of samples	% Red.	% Exc.	# of samples	% Red.	% Exc.
High	2	0.0	0.0	2	NR	0.0
Moist	10	11.8	50.0	4	2.3	50.0
Mid-Range	8	29.2	75.0	3	23.0	66.7
Low	6	**33.1**	**100.0**	1	**60.0**	**100.0**

The priority flow zone for implementation activities is confirmed as the same zone as initial analyses indicated. However, if a different flow zone, or zones, were identified, the flow zone(s) from analysis of recent data would have emphasis for implementation prioritization.

TMDLs, WLAs, LAs, and PLRGs for impaired waterbodies in the Nonconnah Creek Watershed are summarized in Table C-6.

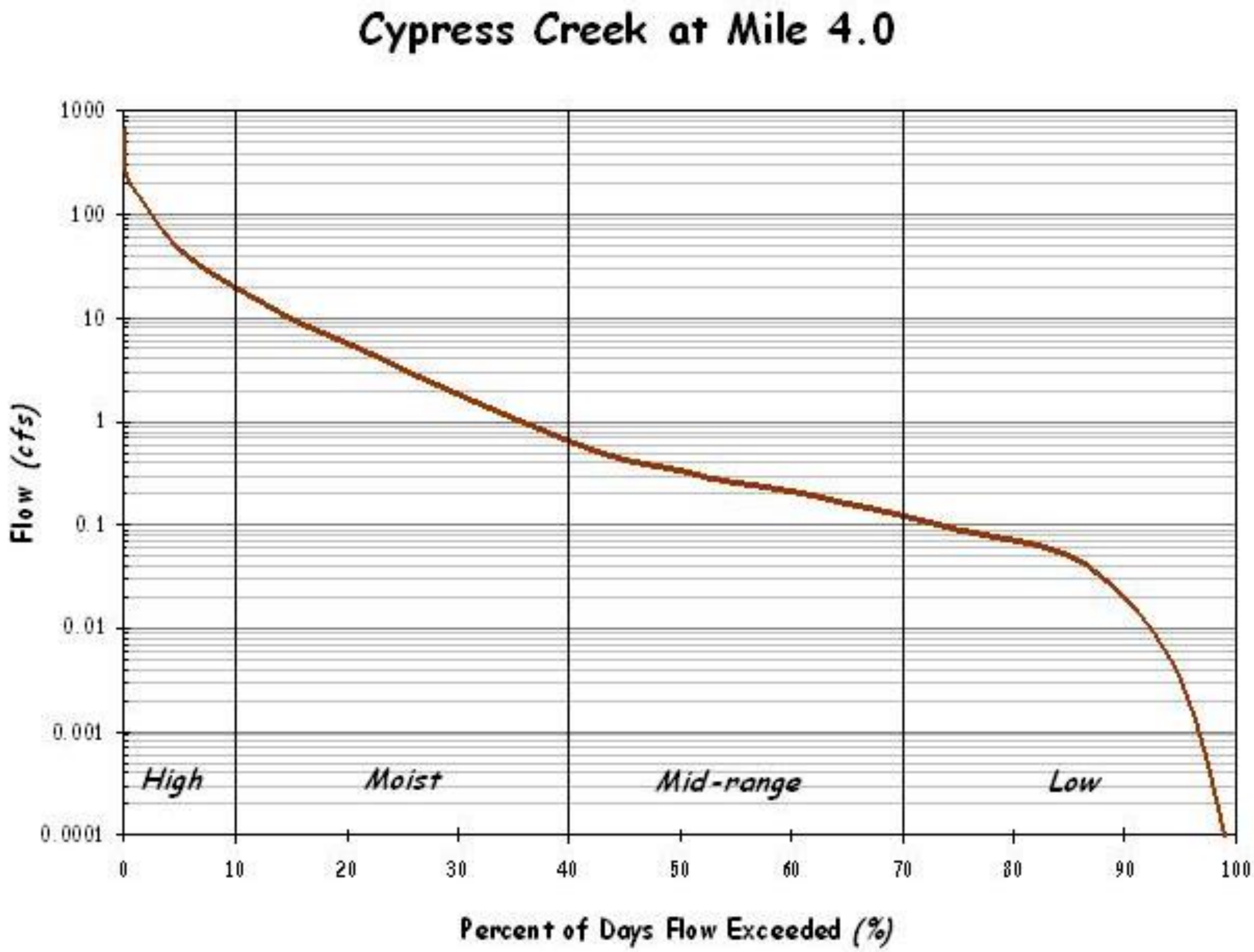

Figure C-1 Flow Duration Curve for Cypress Creek at RM4.0

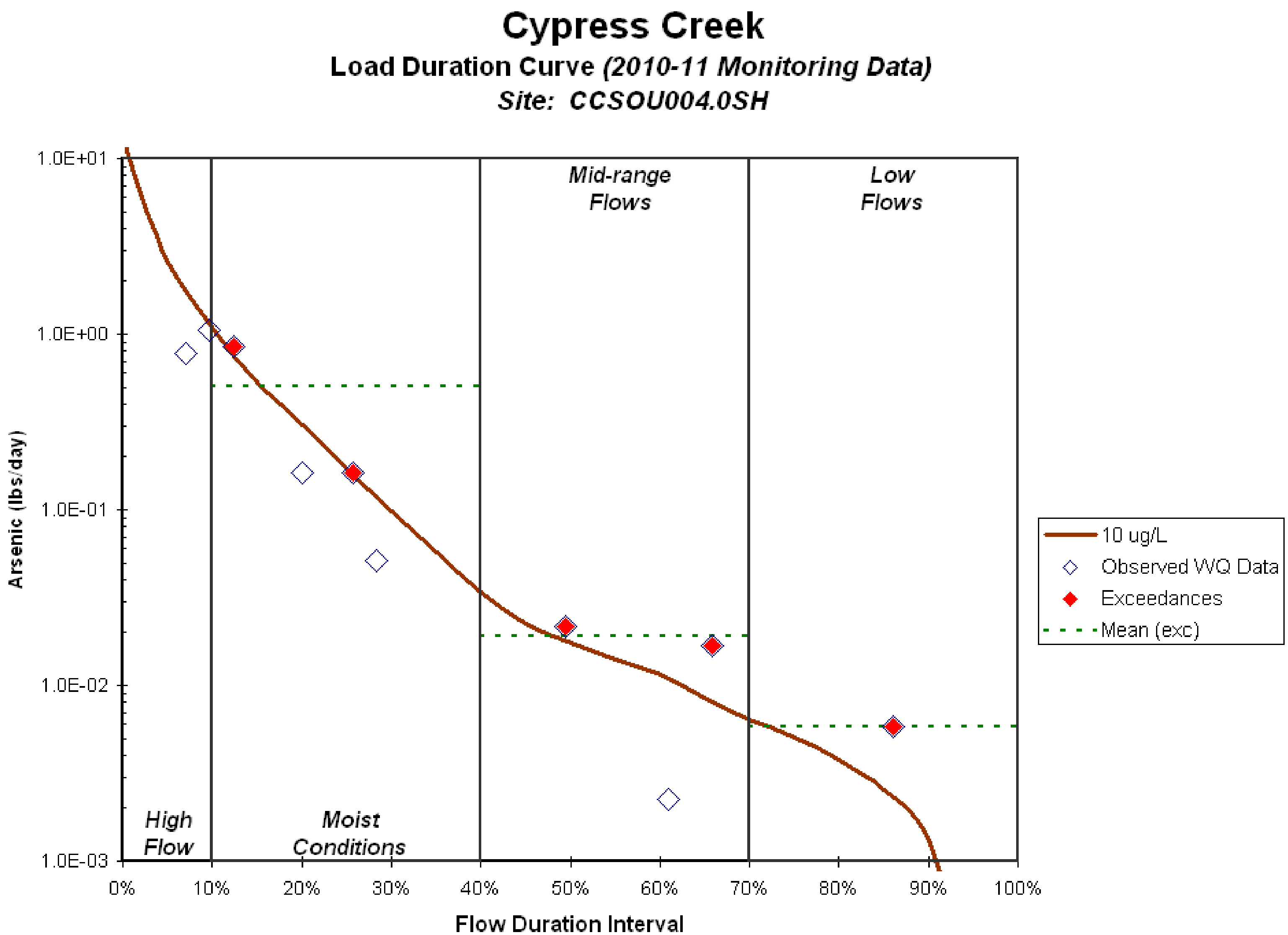

Figure C-2 Arsenic Load Duration Curve for Cypress Creek at RM4.0

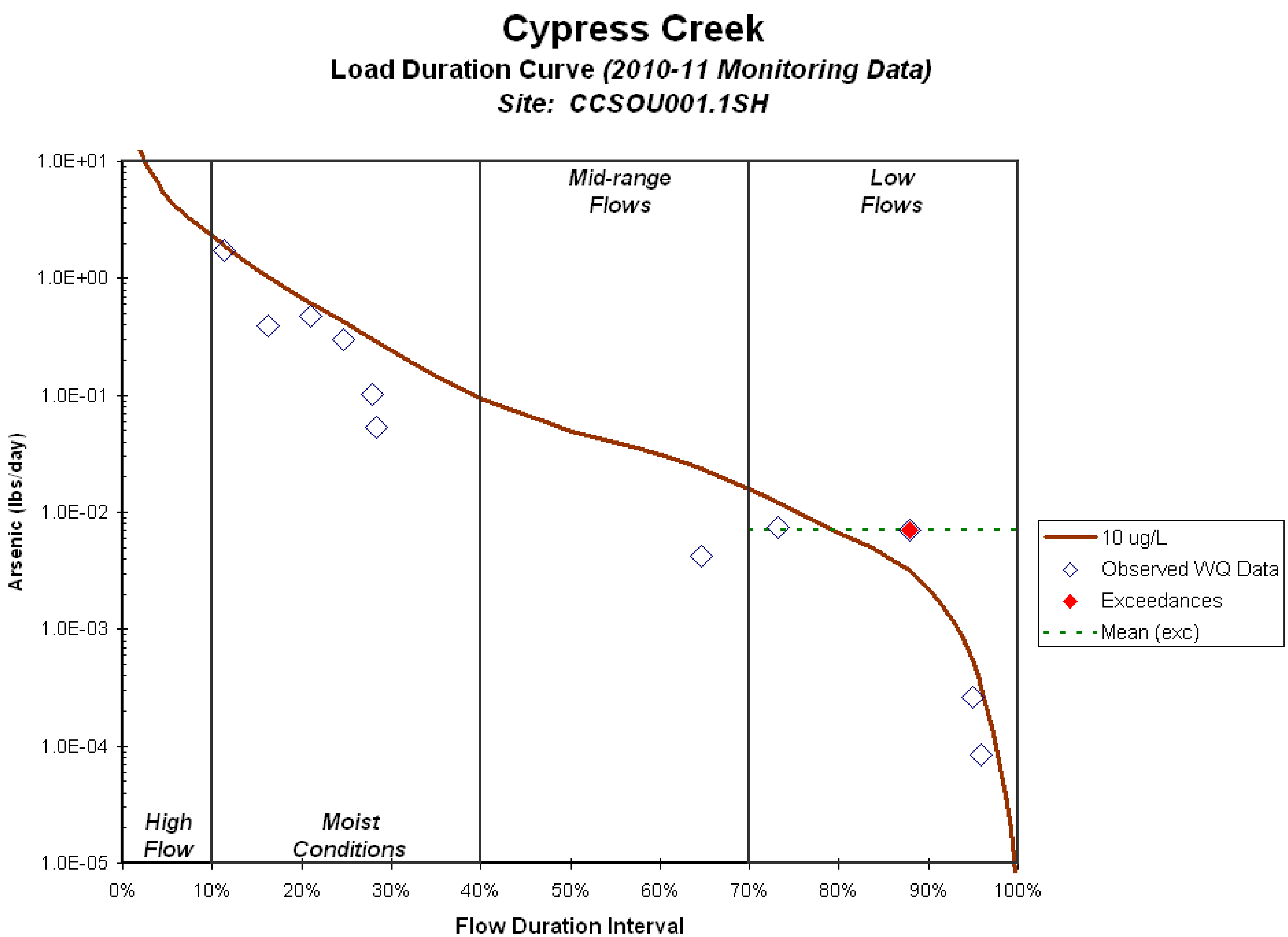

Figure C-3 Arsenic Load Duration Curve for Cypress Creek at Mile 1.1

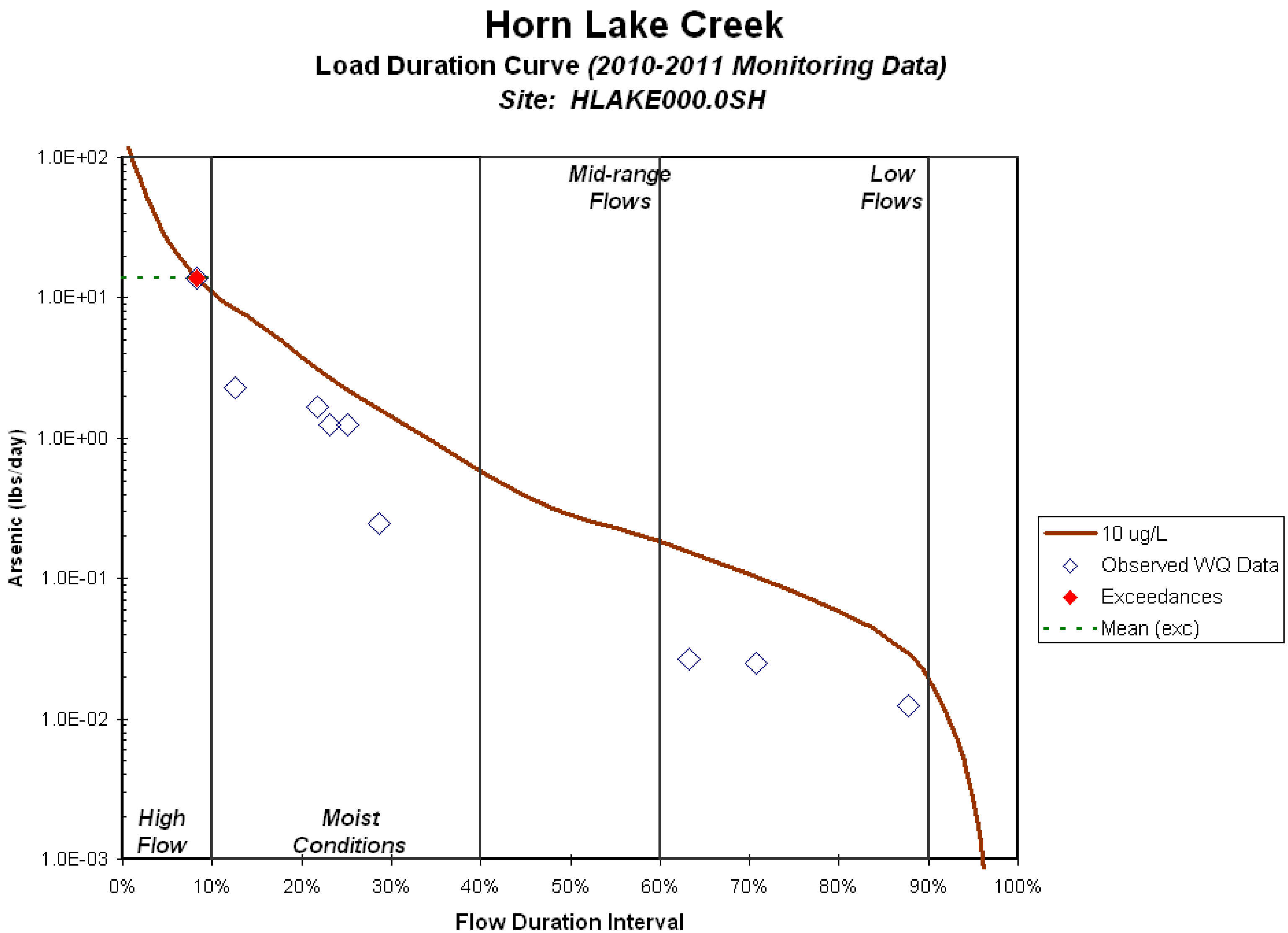

Figure C-4 Arsenic Load Duration Curve for Horn Lake Creek at Mile 0.0

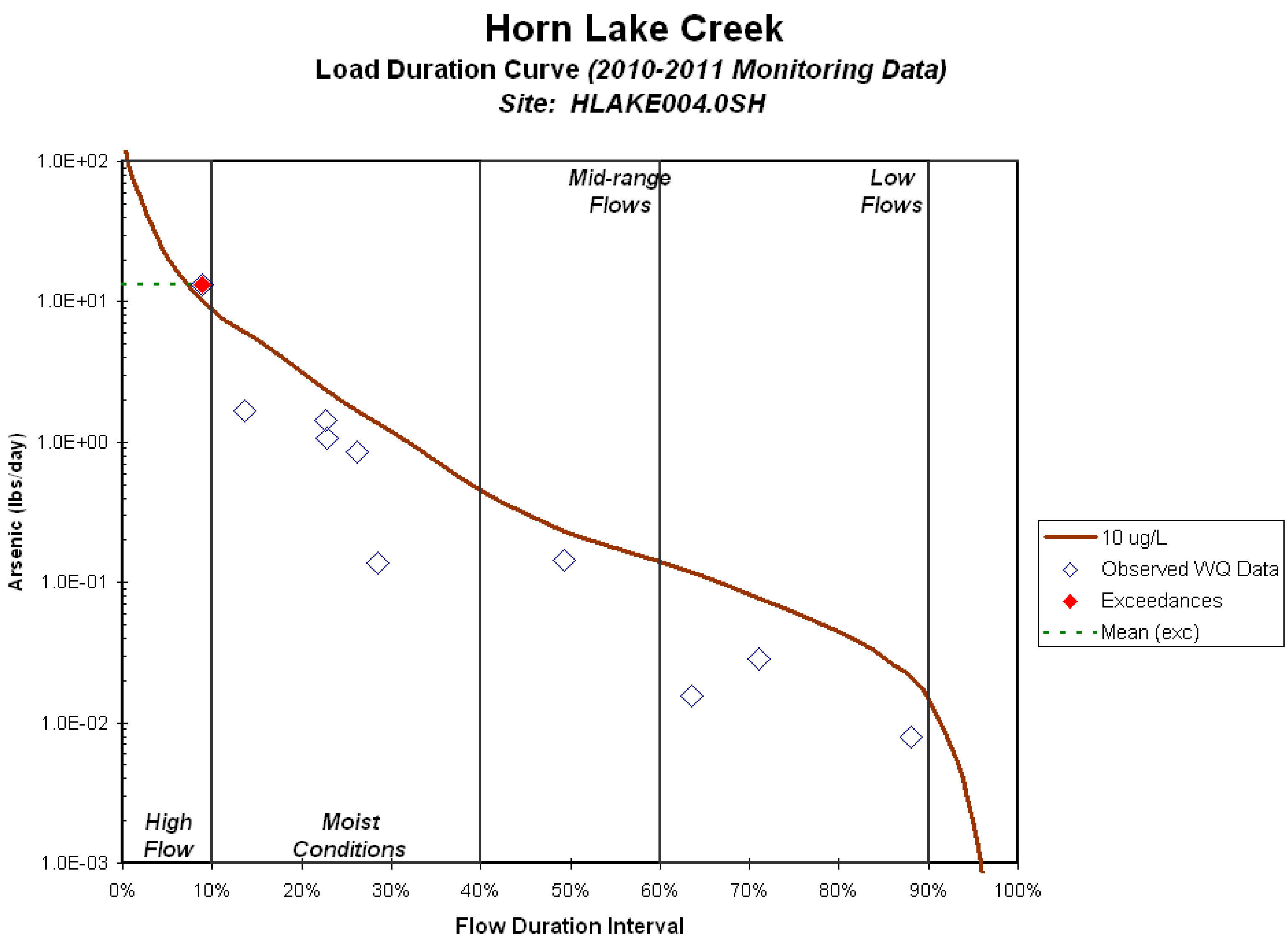

Figure C-5 Arsenic Load Duration Curve for Horn Lake Creek at Mile 4.0

Table C-2. Calculated Load Reduction Based on Daily Loading – Cypress Creek at RM4.0

Sample Date	Flow Regime	Flow	PDFE	Observed Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions
		[cfs]	[%]	[µg/ml]	[lb/day]	[%]	[%]
3/8/11	High Flow	33.00	7.1%	4.4	7.83E-01	NR	**NR**
4/19/11		21.56	9.6%	9	1.05E+00	NR	
7/14/10	Moist Conditions	14.28	12.4%	**11**	8.47E-01	**9.1**	**2.3**
11/17/10		5.64	20.0%	5.3	1.61E-01	NR	
12/13/10		3.04	25.7%	**10**	1.64E-01	**0.0**	
1/27/11		2.26	28.4%	4.2	5.13E-02	NR	
5/17/11	Mid-Range Flows	0.333	49.4%	**12**	2.16E-02	**16.7**	**23.0**
2/16/11		0.199	61.0%	2.1	2.25E-03	NR	
6/7/11		0.149	65.9%	**21**	1.69E-02	**52.4**	
8/18/10	Low Flow	0.043	86.1%	**25**	5.80E-03	**60.0**	**60.0**

Note: NR = No reduction required

Table C-3. Calculated Load Reduction Based on Daily Loading – Cypress Creek at RM1.1

Sample Date	Flow Regime	Flow	PDFE	Observed Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions
		[cfs]	[%]	[μg/ml]	[lb/day]	[%]	[%]
7/14/10	Moist Conditions	36.00	11.4%	8.8	1.71E+00	NR	**NR**
3/8/11		18.97	16.2%	3.8	3.89E-01	NR	
4/19/11		11.57	21.0%	7.5	4.68E-01	NR	
12/13/10		7.92	24.6%	7	2.99E-01	NR	
11/17/10		5.72	27.9%	3.3	1.02E-01	NR	
1/27/11		5.44	28.4%	1.8	5.28E-02	NR	
6/7/11	Low Flow	0.223	73.2%	6.2	7.46E-03	NR	**14.1**
8/18/10		0.057	87.9%	**23**	7.07E-03	**56.5**	
9/22/10		0.012	94.9%	4	2.59E-04	NR	
10/13/10		0.005	95.9%	3.1	8.36E-05	NR	

Note: NR = No reduction required

Table C-4. Calculated Load Reduction Based on Daily Loading – Horn Lake Creek at RM0.0

Sample Date	Flow Regime	Flow	PDFE	Observed Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions
		[cfs]	[%]	[μg/ml]	[lb/day]	[%]	[%]
7/14/10	High Flow	253.5	8.3%	**10**	1.37E+01	**0.0**	**0.0**
3/8/11	Moist Conditions	150.4	12.5%	2.8	2.27E+00	NR	**NR**
12/13/10		56.15	21.8%	5.5	1.67E+00	NR	
4/19/11		49.78	23.1%	4.6	1.24E+00	NR	
1/27/11		41.53	25.1%	5.6	1.25E+00	NR	
11/17/10		30.34	28.7%	1.5	2.45E-01	NR	
2/16/11	Mid-Range Flows	2.93	63.2%	1.7	2.69E-02	NR	**NR**
6/7/11		1.91	70.8%	2.4	2.47E-02	NR	
8/18/10		0.516	87.8%	4.5	1.25E-02	NR	
9/22/10	Low Flow	0.027	95.8%	3.7	5.30E-04	NR	**NR**
10/13/10		0.002	96.8%	2.8	3.31E-05	NR	

Note: NR = No reduction required

Table C-5. Calculated Load Reduction Based on Daily Loading – Horn Lake Creek at RM4.0

Sample Date	Flow Regime	Flow	PDFE	Observed Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions
		[cfs]	[%]	[μg/ml]	[lb/day]	[%]	[%]
7/14/10	High Flow	189.3	8.9%	**13**	1.33E+01	**23.1**	**23.1**
3/8/11	Moist Conditions	113.6	13.6%	2.7	1.65E+00	NR	
12/13/10		43.07	22.7%	6.1	1.42E+00	NR	
4/19/11		42.90	22.8%	4.6	1.06E+00	NR	
1/27/11		31.87	26.2%	4.9	8.42E-01	NR	
11/17/10		25.35	28.5%	1	1.37E-01	NR	**NR**
2/16/11	Mid-Range Flows	2.20	63.5%	1.3	1.55E-02	NR	
6/7/11		1.42	71.1%	3.7	2.83E-02	NR	
8/18/10		0.385	88.0%	3.8	7.89E-03	NR	**NR**
9/22/10	Low Flow	0.017	95.9%	2.4	2.20E-04	NR	
10/13/10		0.001	96.9%	3.5	1.89E-05	NR	**NR**

Note: NR = No reduction required

Table C-6. TMDLs, WLAs, and LAs expressed as daily loads for Impaired Waterbodies in the Nonconnah Creek Watershed (HUC 08010211)

HUC-12 Subwatershed (08010211__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	PLRG	WLAs	LAs [b]
						MS4s [a,b]	Stormwater
			[lbs/day]	[lbs/day]	[%]	[lbs/day/ac]	[lbs/day/ac]
0201	Cypress Creek	TN08010211007 – 1000	$5.39 \times 10^{-2} \times Q$	$5.39 \times 10^{-3} \times Q$	60.0	$5.587 \times 10^{-6} \times Q$	$5.587 \times 10^{-6} \times Q$
0301/0302	Horn Lake Creek	TN08010211001 – 2000	$5.39 \times 10^{-2} \times Q$	$5.39 \times 10^{-3} \times Q$	23.1	$1.303 \times 10^{-6} \times Q$	$1.303 \times 10^{-6} \times Q$
	Horn Lake Cutoff	TN08010211001 – 0100					

Notes: Q = Mean Daily In-stream Flow (cfs).
PLRG = Percent Load Reduction Goal to achieve TMDL.
NR = No reduction required.

a. Applies to any MS4 discharge loading in the subwatershed. Future MS4s will be assigned waste load allocations (WLAs) consistent with load allocations (LAs) assigned to precipitation induced nonpoint sources.

b. WLAs and LAs expressed as a "per acre" load are calculated based on the drainage area at the pour point of the HUC-12 or drainage area.

APPENDIX D

Hydrodynamic Modeling Methodology

HYDRODYNAMIC MODELING METHODOLOGY

D.1 Model Selection

The Windows version of Hydrologic Simulation Program - Fortran (HSPF) was selected for flow simulation of pathogen-impaired waters in the subwatersheds of the Nonconnah Creek Watershed. HSPF is a watershed model capable of performing flow routing through stream reaches.

D.2 Model Set Up

The Nonconnah Creek Watershed was delineated into subwatersheds in order to facilitate model hydrologic calibration. Boundaries were constructed so that subwatershed "pour points" coincided with HUC-12 delineations, 303(d)-listed waterbodies, and water quality monitoring stations. Watershed delineation was based on the NHD stream coverage and Digital Elevation Model (DEM) data. This discretization facilitates simulation of daily flows at water quality monitoring stations.

Several computer-based tools were utilized to generate input data for the WinHSPF model. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display, analyze, and compile available information to support hydrology model simulations for selected subwatersheds. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics.

An important factor influencing model results is the precipitation data contained in the meteorological data files used in these simulations. Weather data from multiple meteorological stations were available for the time period from January 1970 through December 2011. Meteorological data for a selected 12-year period were used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 11-year period (1/1/01 – 12/31/11) used for TMDL analysis.

D.3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from U. S. Geological Survey (USGS) stream gaging stations for the same period of time. A USGS continuous record station located in the Nonconnah Creek Watershed was selected as the basis of the hydrology calibration. Station 07032200 is located on Nonconnah Creek near Germantown, TN and has a drainage area of 68.2 square miles. Station 07032200 is located in ecoregion 74B, as is most of the Nonconnah Creek Watershed, and is representative of the landuse and topography of the Nonconnah Creek Watershed.

Initial values for hydrologic variables were taken from an EPA developed default data set. During the calibration process, model parameters were adjusted within reasonable constraints until acceptable agreement was achieved between simulated and observed streamflow. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

The results of the hydrologic calibration for Nonconnah Creek near Germantown, USGS Station 07032200, are shown in Table D-1 and Figures D-1 and D-2.

Table D-1. Hydrologic Calibration Summary: Nonconnah Creek near Germantown (USGS 07032200)

		66.844228	
Simulation Name:	USGS07032200	**Simulation Period:**	
		Watershed Area (ac):	42794.00
Period for Flow Analysis			
Begin Date:	**01/01/97**	**Baseflow PERCENTILE:**	2.5
End Date:	**12/31/20006**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**234.01**	Total Observed In-stream Flow:	**226.62**
Total of highest 10% flows:	**186.79**	Total of Observed highest 10% flows:	**186.29**
Total of lowest 50% flows:	**2.95**	Total of Observed Lowest 50% flows:	**2.17**
Simulated Summer Flow Volume (months 7-9):	**19.05**	Observed Summer Flow Volume (7-9):	**20.67**
Simulated Fall Flow Volume (months 10-12):	**67.29**	Observed Fall Flow Volume (10-12):	**56.96**
Simulated Winter Flow Volume (months 1-3):	**92.00**	Observed Winter Flow Volume (1-3):	**93.00**
Simulated Spring Flow Volume (months 4-6):	**55.66**	Observed Spring Flow Volume (4-6):	**55.99**
Total Simulated Storm Volume:	**234.01**	Total Observed Storm Volume:	**226.62**
Simulated Summer Storm Volume (7-9):	**19.05**	Observed Summer Storm Volume (7-9):	**20.67**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**3.26**	10	
Error in 50% lowest flows:	**35.93**	10	
Error in 10% highest flows:	**0.27**	15	
Seasonal volume error - Summer:	**-7.81**	30	
Seasonal volume error - Fall:	**18.14**	30	
Seasonal volume error - Winter:	**-1.08**	30	
Seasonal volume error - Spring:	**-0.59**	30	
Error in storm volumes:	**3.26**	20	
Error in summer storm volumes:	**-7.81**	50	

Criteria for Median Monthly Flow Comparisons	
Lower Bound (Percentile):	25
Upper Bound (Percentile):	75

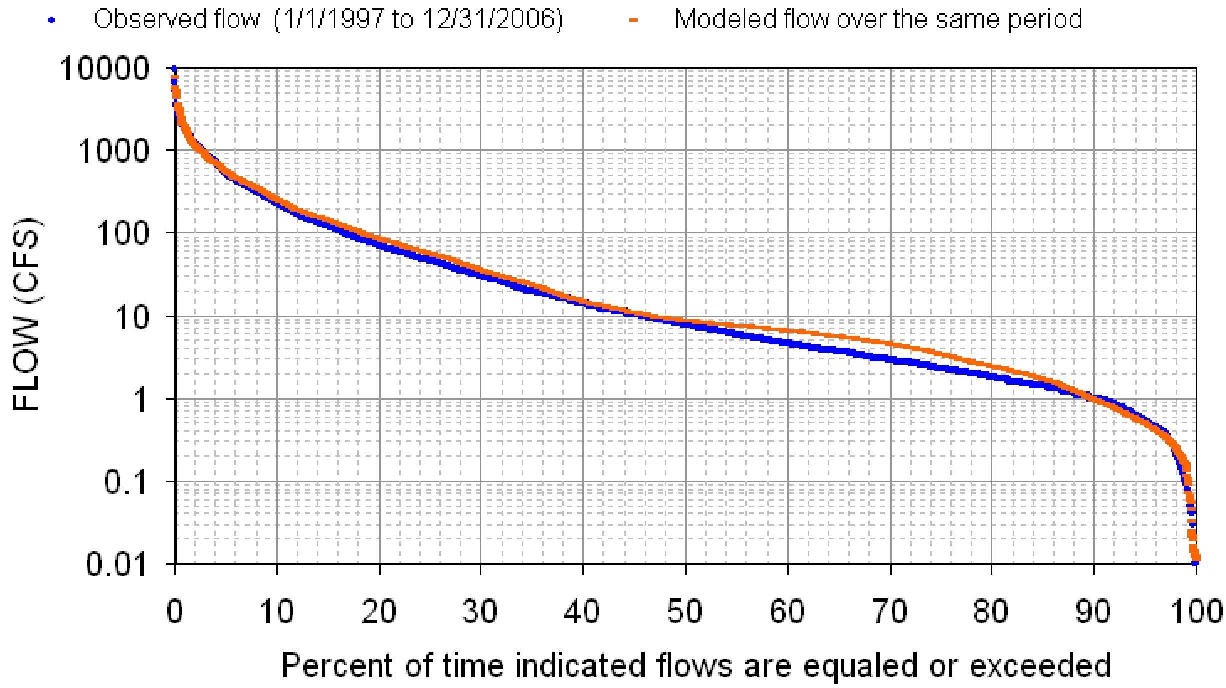

Figure D-1. Hydrologic Calibration: Nonconnah Creek, USGS 07032200 (CYs1997-2006)

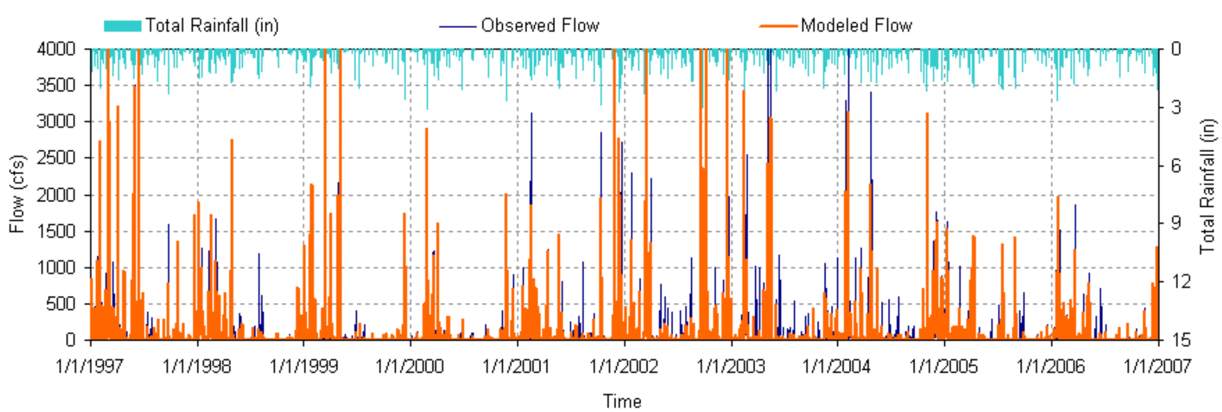

Figure D-2. 10-Year Hydrologic Comparison: Nonconnah Creek, USGS 07032200

APPENDIX E

Comparison of Two Date Ranges

Sufficient data was available at all monitoring stations to compare two 5-year time periods: 2001-2002 and 2010-2011.

The condition of Cypress Creek at RM1.1 appears to have improved. During the 2001-2002 sampling period, there were exceedances in 3 of the 4 flow regimes. During the 2010-2011 sampling period, the only exceedances were in the low flow regime and the mean of the exceedances was lower than in the 2001-2002 sampling period.

However, the condition of Cypress Creek at RM4.0 appears to be unchanged. There were exceedances in 3 of the 4 flow regimes during both time periods and the differences were not significant.

The condition of Horn Lake Creek shows some improvement. During the 2001-2002 sampling period, there were exceedances in 2 (RM0.0) or 3 (RM4.0) of the 4 flow regimes. During the 2010-2011 sampling period, there was only one exceedance. However, the exceedance occurred in the high flow regime, which had not previously been sampled. Investigation of three rain gauges in adjacent watersheds (Memphis International Airport, and Holly Springs, and Arkabutla Dam, MS) confirm that approximately one inch of rain fell on the previous day. According to the Mt. Pleasant rain gage, it was raining at the time the sample was taken. This could have been a contributing factor.

The condition of the Horn Lake Cutoff could not be determined due to lack of monitoring data.

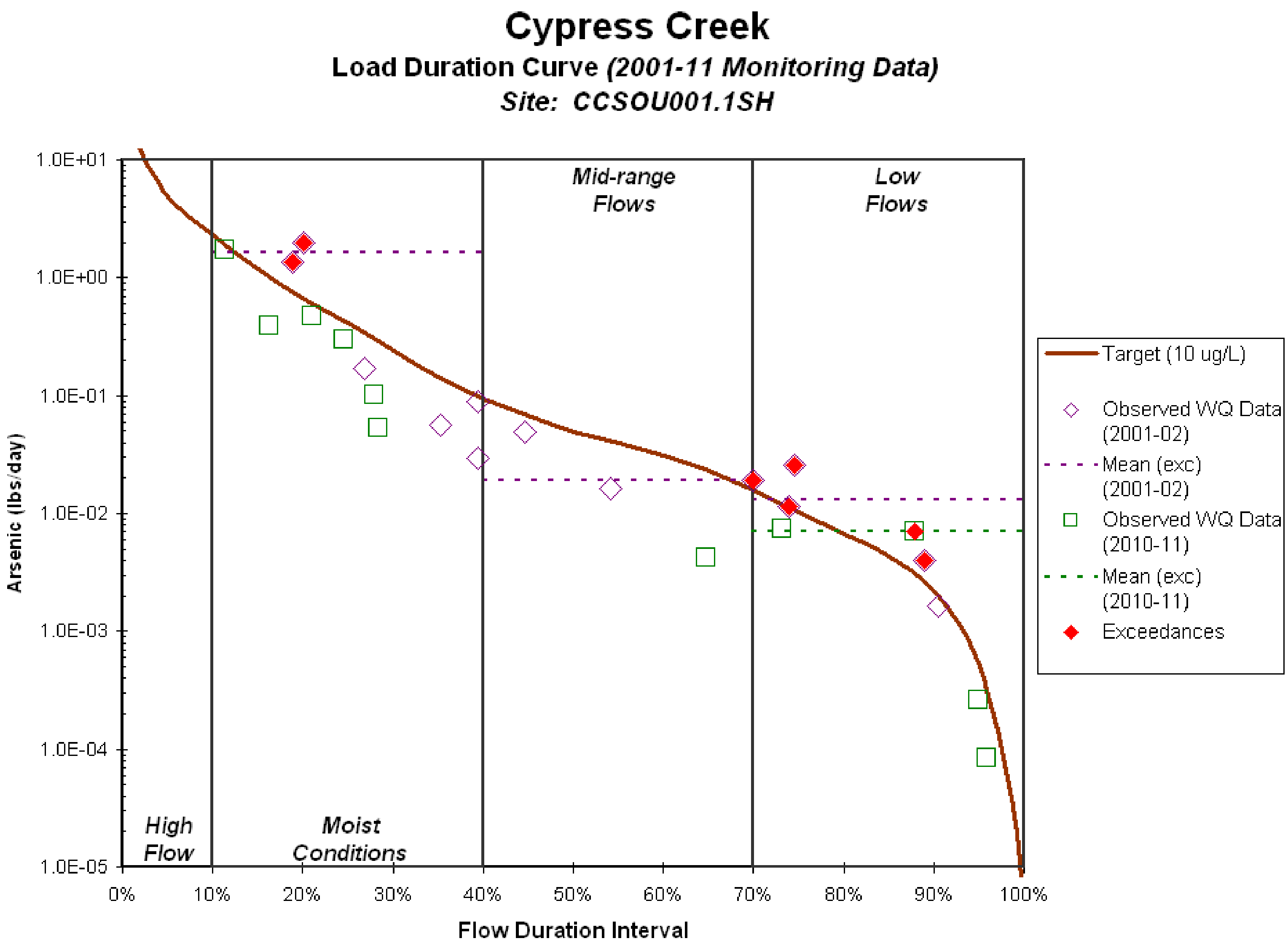

Figure E-1 Arsenic Load Duration Curve for Cypress Creek at Mile 1.1

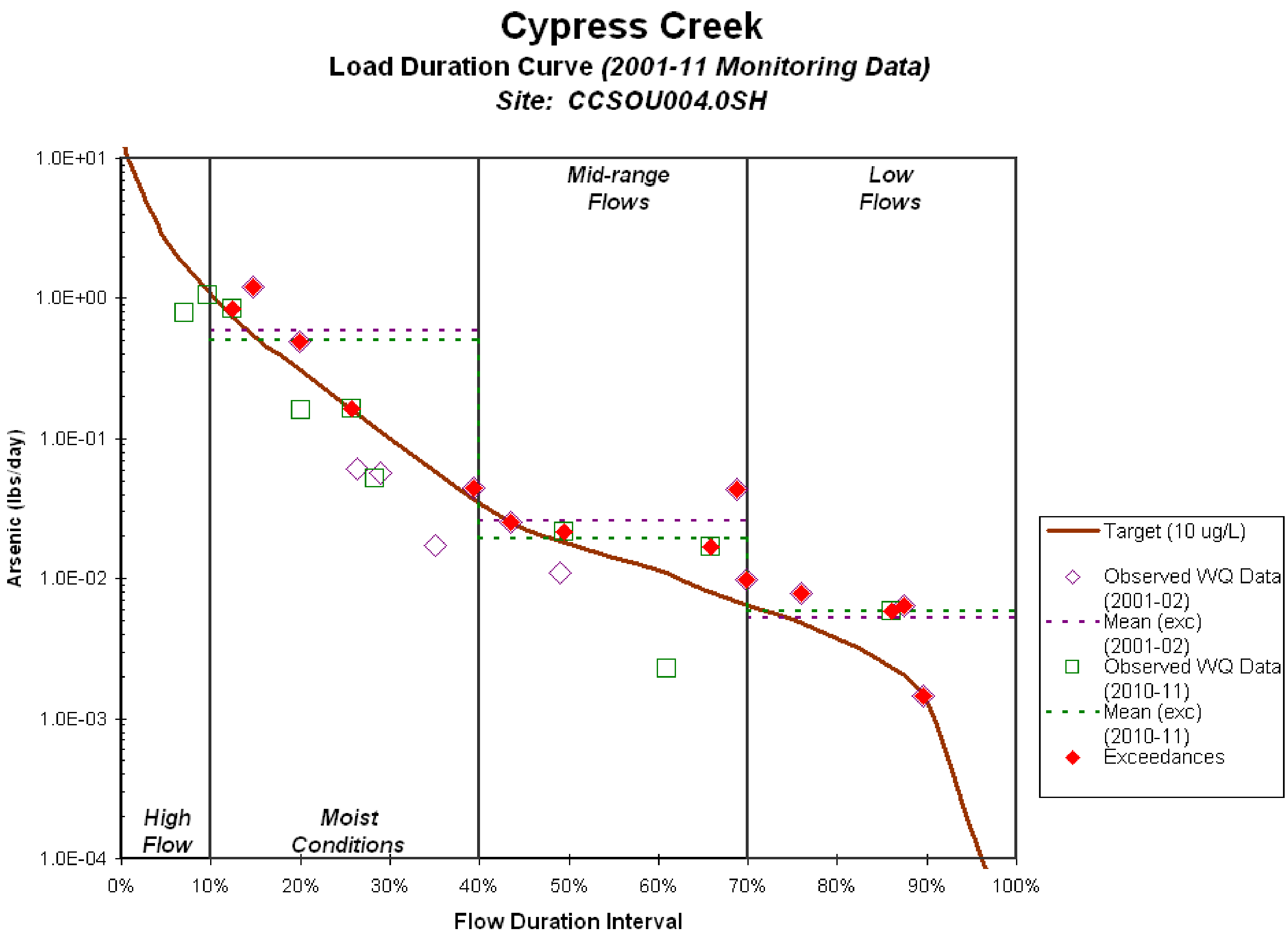

Figure E-2 Arsenic Load Duration Curve for Cypress Creek at Mile 4.0

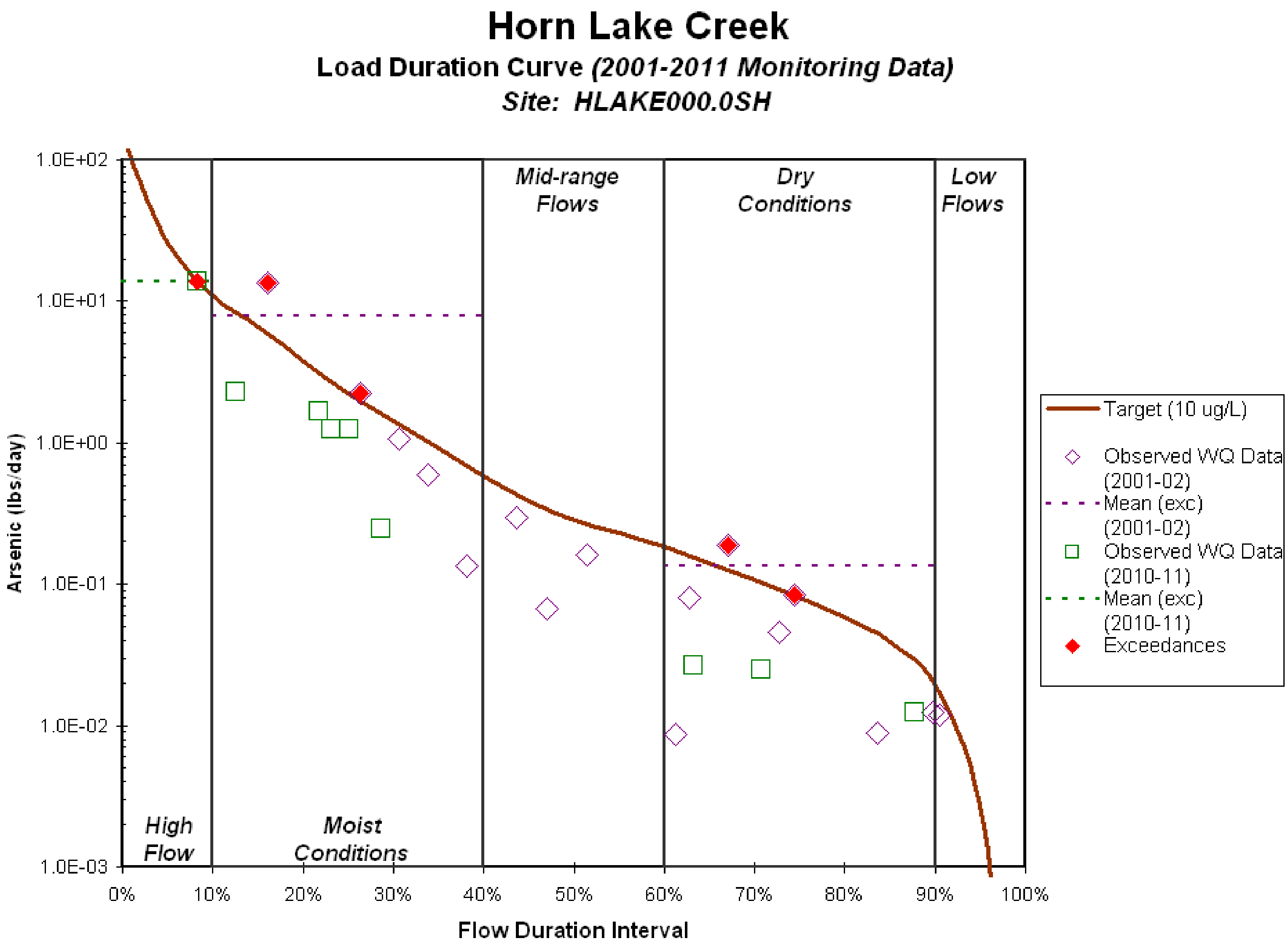

Figure E-3 Arsenic Load Duration Curve for Horn Lake Creek at Mile 0.0

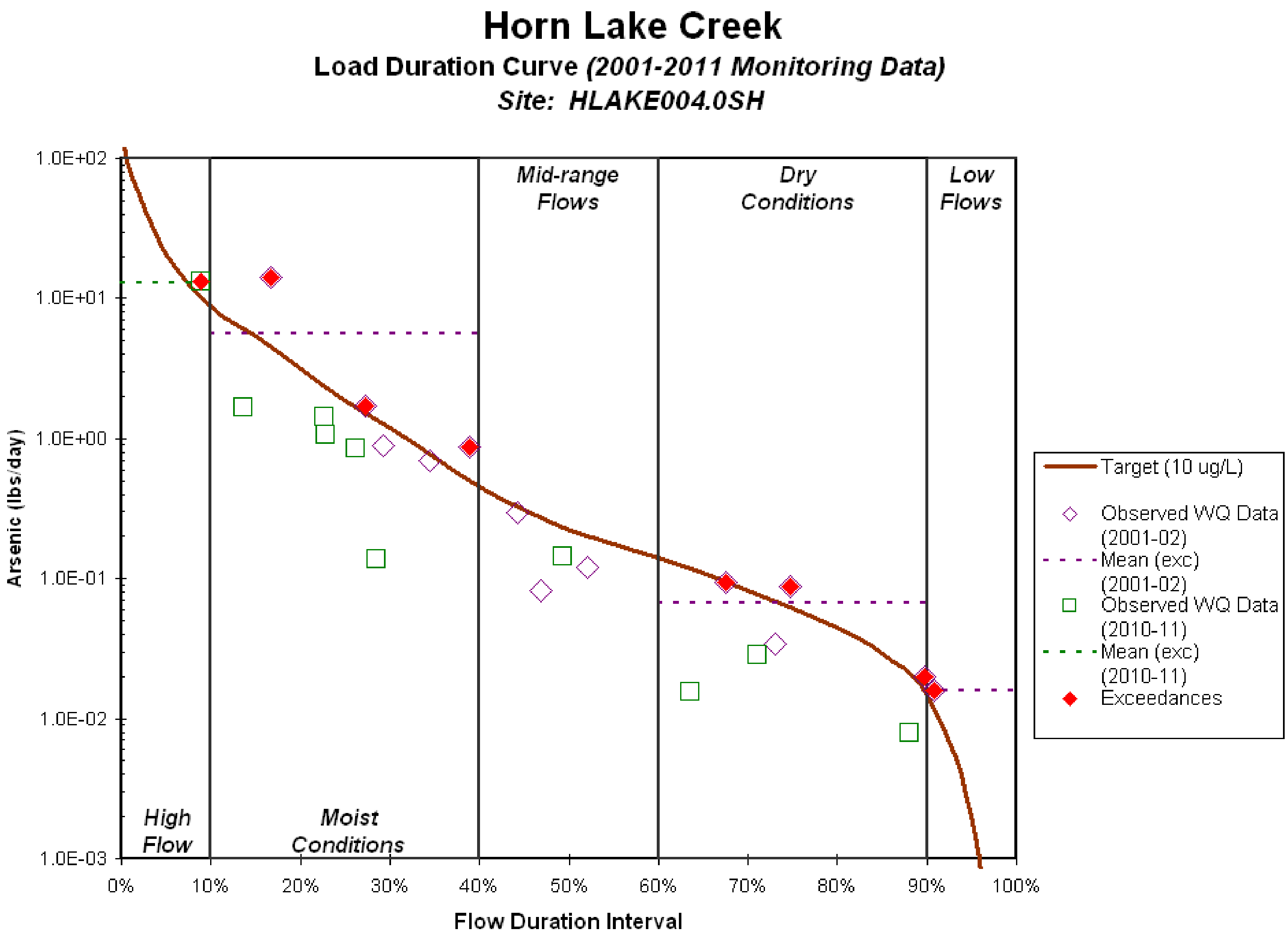

Figure E-4 Arsenic Load Duration Curve for Horn Lake Creek at Mile 4.0

APPENDIX F

Public Notice Announcement

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER RESOURCES

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR ARSENIC IN NONCONNAH CREEK WATERSHED (HUC 08010211), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Load (TMDL) for arsenic in the Nonconnah Creek watershed, located in western Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

A number of waterbodies in the Nonconnah Creek watershed are listed on Tennessee's Proposed Final 2012 303(d) list as not supporting designated use classifications due, in part, to discharges from MS4 areas. The TMDL utilizes Tennessee's general water quality criteria, continuous flow data from a USGS discharge monitoring station located in proximity to the watershed, site specific water quality monitoring data, a calibrated hydrologic model, load duration curves, and an appropriate Margin of Safety (MOS) to establish allowable loadings of pathogens which will result in the reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions of arsenic loading on the order of 23.1-60.0% in the listed waterbodies.

The Nonconnah Creek Arsenic TMDL may be downloaded from the Department of Environment and Conservation website:

http://www.tn.gov/environment/water/water-quality_total-daily-maximum-loads.shtml

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Resources staff:

Vicki S. Steed, P.E., Watershed Management Section
Telephone: 615-532-0707

Sherry H. Wang, Ph.D., Watershed Management Section
Telephone: 615-532-0656

Persons wishing to comment on the proposed TMDLs are invited to submit their comments in writing no later than February 24, 2014 to:

Department of Environment and Conservation
Division of Water Resources
Watershed Management Section
William R. Snodgrass Tennessee Tower
312 Rosa L. Parks Avenue, 11th Floor
Nashville, TN 37243

All comments received prior to that date will be considered when revising the TMDL for final submittal to the U.S. Environmental Protection Agency.

The TMDL and supporting information are on file at the Division of Water Resources, William R. Snodgrass Tennessee Tower, 312 Rosa L. Parks Avenue, 11th Floor, Nashville, Tennessee 37243. They may be inspected during normal office hours. Copies of the information on file are available on request.

APPENDIX G

Public Comments Received

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
675 US Courthouse
801 Broadway
Nashville, Tennessee 37203

TN DEPT OF ENVIRONMENT AND CONSERVATION
FEB 13 2014
DIV OF WATER RESOURCES
RECEIVED

February 12, 2014

Sherry Wang, Ph.D.
Tennessee Department of Environment and Conservation
312 Rosa L. Parks Boulevard, 11th Floor
Nashville, Tennessee 37243

Subject: Draft of Proposed Total Maximum Daily Load (TMDL) for Arsenic, Nonconnah Creek Watershed, Tennessee

Dear Dr. Wang:

Thank you for the opportunity to comment on the proposed draft TMDL for arsenic in Nonconnah Creek. The report was informative about sources for arsenic from point and nonpoint sources and development of agricultural lands.

We will forward a copy of the TMDL to NRCS area and field offices in the Nonconnah Creek watershed, along with a copy of EPA's resource document, "Use of Best Management Practices in Urban Watersheds," to assist citizens and municipalities that may come to NRCS offices for information about nonpoint source control.

Sincerely,

Kevin Brown

KEVIN BROWN
State Conservationist

cc: Carol Chandler, State Resource Conservationist, NRCS, Nashville, TN
Craig Ellis, Area Conservationist, NRCS, Jackson, TN
Frank Sagona, Biologist, NRCS, Chattanooga, TN
Frederick Walker, District Conservationist, NRCS, Memphis, TN
David Dees, District Conservationist, NRCS, Somerville, TN

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February 20, 2014

Tennessee Department of Environment and Conservation
Division of Water Resources
Watershed Management Section
William R. Snodgrass Tower
312 Rosa L. Parks Avenue, 11th Floor
Nashville, TN 37243

Re: Comments on Proposed Metals Total Maximum Daily Load for the Nonconnah Creek Watershed

The Tennessee Department of Environment and Conservation (TDEC) has recently issued a draft document for public comment presenting a proposed Total Maximum Daily Load (TMDL) for Arsenic in the Nonconnah Creek Watershed (HUC 08010211). In Section 6.1.2 of that document, the Tennessee Department of Transportation (TDOT) Municipal Separate Storm Sewer System (MS4), regulated under Permit TNS077585, is listed as a point source for the pollutant loading that is the subject of the TMDL. Inclusion as a point source will trigger requirements in the TDOT MS4 Permit that could include stormwater effluent monitoring, in-stream monitoring, and the implementation of control measures at discharge points. The TDOT MS4 discharges to most streams within the state of Tennessee. TDOT's necessary approach in applying its finite resources that can be devoted to improving water quality is to focus on those locations where the efforts can truly be beneficial and cost effective. TDOT does not believe that the inclusion of its MS4 as a point source for the pollutant loading which is the subject of this TMDL is consistent with this approach and requests that the subject document be modified to remove the TDOT MS4 as a point source.

The rationale for this request includes the following points:

1. **Arsenic contamination has not typically been attributed to highway stormwater runoff.** Numerous studies of the contaminants in highway runoff have been performed by various government agencies, and arsenic has not typically been considered to be a contaminant of concern. See for example the following major studies of highway runoff water quality which did not consider arsenic to be a contaminant of concern for runoff from highways:

- Federal Highways Administration (FHWA), Guidance Manual for Monitoring Highway Runoff Water Quality, Publication No. FHWA-EP-01-022, June 2001 http://www.environment.fhwa.dot.gov/ecosystems/h2o_runoff/h2oroff.pdf
- Transportation Research Board, Mobilization of Major and Trace Constituents of Highway Runoff in Groundwater Potentially Caused by Deicing Chemical Migration, Transportation Research Record 1483 (1995) http://www.webdmamrl.er.usgs.gov/g1/ggranato/TRB1483.pdf
- United States Geologic Survey (USGS), A Synopsis of Technical Issues of Concern for Monitoring Trace Elements in Highway and Urban Runoff, USGS Open-File Report 00-422, 2000 http://webdmamrl.er.usgs.gov/g1/FHWA/products/ofr00-422.pdf
- FHWA Highway Runoff Database, Publication no. FHWA-HEP-09-004, 2009 http://webdmamrl.er.usgs.gov/g1/FHWA/FHWA-HEP-09-004/FHWA-HEP-09-004.pdf
- Michigan Department of Transportation Highway Stormwater Runoff Study http://www.michigan.gov/documents/MDOT_MS4_MDOT_Hwy_SW_Runoff_Study_91946_7.pdf
- FHWA, Sources and Migration of Highway Runoff Pollutants, Report No. FHWA/RD-84/057, May 1984 http://ntl.bts.gov/lib/31000/31300/31326/FHWA-RD-84-057.pdf
- FHWA, Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring http://environment.fhwa.dot.gov/ecosystems/ultraurb/uubmp2.asp#s221

2. **The drainage area of the TDOT MS4 which contributes to the subject watershed is a negligible portion of the overall watershed area.** The subject TMDL affects a total of three impaired stream segments in the Nonconnah Creek Watershed. Those three stream segments include designated portions of:

   - Horn Lake Cutoff (TN08010211001 - 0100)
   - Horn Lake Creek (TN08010211001 - 2000)
   - Cypress Creek (TN08010211007 - 1000)

   Data from TDOT's outfall mapping program has determined that the TDOT MS4 has point source discharges to the Cypress Creek and Horn Lake Creek stream segments at 79 stormwater outfall locations. The TDOT MS4 does not discharge to the Horn Lake Cutoff subwatershed. The total area within the TDOT MS4 that drains to the three subwatersheds is calculated to be 150.4 acres. However, the total drainage area of the three impaired stream segment subwatersheds is 61,556.2 acres. The TDOT MS4 drainage area contributing to the watersheds of these stream segments is less than 0.24% of the overall impaired watershed drainage areas and, assuming that the drainage area would be roughly proportional to the volume of stormwater discharge to the stream segments, the TDOT MS4 is clearly a negligible contributor to this hydrologic system. If the TDOT MS4 could somehow completely eliminate its stormwater discharges to the subject stream segments, the ultimate effect would be imperceptible.

   Additionally, numerous sources in the literature have found that impervious areas within a watershed do not significantly impact water quality until the impervious area exceeds 10% of the watershed area (see for example: www.epa.gov/athens/publications/LindaNWQMC.doc). The TDOT MS4 drainage area value of 0.24% is the total drainage area of the TDOT Right-of-Way, including both the impervious roadway and any adjacent pervious shoulders, ditches, swales, and vegetated areas. Thus, the actual effective impervious area of the TDOT MS4 would be expected to be significantly lower than 0.24%. The TDOT MS4 is only accountable for contamination that originates within its boundaries. A recent U.S. Supreme Court decision (*Los Angeles*

County Flood Control District v. Natural Resources Defense Council, et al., No. 11-460 (U.S. 2013)) has found that a MS4 cannot be held responsible for stormwater contaminants that originated off its jurisdiction. Conversely, the Memphis and Bartlett MS4 areas encompass almost the entire drainage areas of the impaired sub-watersheds.

3. **Post-construction highway run-off from the TDOT MS4 is not a significant source of solids contamination in stormwater.** Section 6.1.2 of the subject document contains the following paragraph:

   "In addition to traffic density, the pavement condition and compactation are significant in determining the traffic impact on pollution accumulation. Streets paved entirely with asphalt have total solids loadings about 80% higher than all concrete streets. Streets whose conditions were rated "fair-to-poor" were found to have total solids loadings 2.5 times greater than those rated "good-to-excellent." (Novotny, 1981)"

   This paragraph appears to suggest that there is some link between solids loading from highway runoff and arsenic contamination. If that is the intent, TDOT disagrees with this supposition on several counts. First, the referenced source is over 30 years old. The materials of construction and the methods of highway paving have advanced significantly over the past 30 years and any data acquired in the 1970's has no validity today. TDOT highways are typically re-paved every 10-12 years. Additionally, The TDOT MS4 Program has been acquiring and analyzing actual samples of stormwater runoff from state highways in Tennessee over the past four years. These samples have been acquired from a variety of highway scenarios across the State, ranging from high traffic volume interstate highways in urban commercial areas to low traffic volume highways in rural agricultural areas. The sampling sites were selected to ensure that the runoff was exclusively from the TDOT ROW and was minimally impacted from non-roadway runoff. To date, a total of 278 stormwater samples from the TDOT MS4 have been evaluated for Total Suspended Solids (TSS). The average result from the analysis of these samples is 43.7 mg/L. This value is less than one-third the benchmark value of 150 mg/L in the Tennessee Storm Water Multi-Sector Draft General Permit for Industrial Activities. Contrary to the common paradigm, **post-construction** highway run-off is not a significant source of solids contamination in stormwater.

   Finally, a study performed by the Massachusetts Institute of Technology (MIT) specifically attempted to correlate arsenic contamination in a pond with highway runoff. The results of this study clearly demonstrated that there was no relationship between the highway runoff and the observed arsenic loading (reference: An Investigation of Arsenic in Spy Pond, Kathryn McLaughlin, MIT, June 1999).

4. **The TDOT MS4 would not be able to quantitatively demonstrate compliance with the specified Waste Load Allocations (WLAs) or Percent Load Reduction Goals (PLRGs).** The WLAs prescribed in the subject TMDL document for MS4s are:
   - $5.587 \times 10^{-6} \times Q$ lbs/day/acre (Cypress Creek subwatershed)
   - 1.303 x 10-6 x Q lbs/day/acre (Horn Lake Creek and Horn Lake Cutoff subwatersheds)

   The term "Q" is defined as the mean daily in-stream flow (cubic feet per second).

Because of the unique nature of the discharges from the TDOT MS4, TDOT does not believe it is possible for it to quantitatively demonstrate compliance to these numeric criteria, for the following reasons:

- The TDOT MS4 discharges to the Cypress Creek and Horn Lake Creek stream segments at only 79 discrete (i.e. point source) outfall locations. However, outfall mapping and sampling research has demonstrated that most of these outfalls not only discharge stormwater from the TDOT MS4 but also stormwater which originated from adjacent MS4 and non-MS4 properties that ran-on to the TDOT MS4. Again, the TDOT MS4 is only accountable for contamination that originates within its boundaries. As mentioned previously, a recent U.S. Supreme Court decision (*Los Angeles County Flood Control District v. Natural Resources Defense Council, et al.*, No. 11-460 (U.S. 2013)) has found that a MS4 cannot be held responsible for stormwater contaminants that originated off its jurisdiction. There would be no reasonable way to differentiate between the quantity of contaminants which originated on the TDOT MS4 with those that originated off-site to define the "lbs" term in the WLA.
- The discharge from the 79 TDOT outfalls is produced in direct response to rainfall events. The TDOT MS4 Program has been acquiring and analyzing actual samples of stormwater runoff from state highways in response to rainfall events throughout Tennessee over the past four years. These rainfall events can vary significantly in the amount of rainfall, the intensity of the rainfall, and the duration of the storm event. All of these factors have been shown to affect the quantity of discharge and concentration of contaminants in the run-off. Other factors that are unique to each rainfall event, such as antecedent precipitation, can also impact the quantity and nature of the discharge. Delineating the quantity of contamination (i.e. the "lbs" term in the WLA) that would be produced by the discharges from these 79 outfall locations to any single rainfall event without direct sampling of each outfall would be impossible.
- The WLA is a function of the "mean daily in-stream flow" of the receiving waterbody. Since the TDOT MS4 discharges at 79 discrete stream locations throughout the watershed, TDOT would have to monitor the stream flow at each location for each discharge producing rainfall event for the WLA to be accurately evaluated. The cost and level of effort necessary to acquire this information would be significant and would not be a prudent expenditure of State of Tennessee resources.
- Although TDOT has defined the total area of the MS4 within the subject watershed, this area is much greater than the actual area which drains to the discrete outfall points. Most of the area within the TDOT MS4 drains in a sheet-flow manner to the pervious shoulders, ditches and vegetated swales which usually border the impervious roadway. This stormwater is infiltrated into the soil or runs-off the MS4 as a non-point source discharge. Additionally, the effective drainage area for each outfall is a function of the conditions during the rainfall event, such as rainfall intensity, antecedent precipitation, and wind velocity, among others. Thus, it is virtually impossible to quantify the effective drainage area of the TDOT MS4 for any given rainfall event and the "per acre" term in the WLA cannot be defined.
- Multiple federal court cases have defined that the "per day" term in a TMDL must be evaluated on a daily basis. For example, the U.S. Court of Appeals for the D.C. Circuit in *Friends of the Earth, Inc. v. EPA, et al.*, (No. 05-5015, April 25,

2006) found that nothing in the language of 33 U.S.C. § 1313 suggested that the EPA was authorized to approve total maximum loads that could be evaluated other than on a daily basis. The court's decision included the comment: "Daily connotes every day," said Judge Tatel. "Daily means daily, nothing else." This principle was reaffirmed in the Federal court case *Virginia Department of Transportation, et al, v. EPA, et al.*, No. 12-775 (E.D. Va. 2013). The TDOT MS4 does not discharge to the impaired stream segments on a daily basis, but likely only 40 to 60 days per year, and thus demonstrating a "daily" loading would seem impractical. For example, would TDOT be able to distribute the observed arsenic levels in its stormwater discharge from a rainfall event over the preceding antecedent dry days? Thus, the "per day" term in the WLA could not be reasonably and accurately evaluated for the discharges from the TDOT MS4 and applying this TMDL to the TDOT MS4 is not valid.

- The TMDL document also prescribes a "Percent Load Reduction Goal (PLRG)" as alternate criteria to the WLAs to demonstrate compliance. This criterion is a percentage reduction in the current arsenic loading. However, the document does not give any indication as to the source or nature of the baseline arsenic levels to which the percentage reduction would be applied. For TDOT to establish a current baseline of arsenic levels in its discharges, stormwater sampling at its 79 outfalls would have to be performed for at least a year. This could require over 4700 sample acquisitions and analyses, with a cost to TDOT that could exceed \$10 million. This would not be a prudent expenditure of State of Tennessee resources.

The stormwater runoff from the TDOT MS4 has been shown to be an unlikely source of arsenic contamination and a negligible contributor to the hydrologic regime of the subject watershed based upon a comprehensive consideration of multiple factors discussed above, including:

- the evaluation of multiple stormwater runoff studies regarding the very limited potential contribution of highway runoff to arsenic contamination of surface water;
- the analysis of the relative area of the TDOT MS4 to the subject watersheds which demonstrate that the TDOT MS4 drainage area contributing to the watersheds of these stream segments is less than 0.24% of the overall impaired watershed drainage areas and that the TDOT MS4 is clearly a negligible contributor to this hydrologic system; and
- Tennessee specific stormwater sampling results which demonstrate the low levels of sediment contamination which originate from TDOT highways.

Additionally, due to the unique nature of the discharges from the TDOT MS4 to the subject watershed, quantitatively demonstrating compliance to the specified numeric WLA criteria would not be possible. Expending State of Tennessee resources to attempt to characterize the unlikely contaminant contribution of the TDOT MS4 to this watershed does not appear to be prudent. Based on this information, TDOT respectfully requests that this draft TMDL document be revised to remove the TDOT MS4 as a possible source for the subject contamination.

If you have any questions, or require additional information or documentation, please call me at 615-741-4732 or email me at Barry.Brown@tn.gov.

Sincerely,

Barry C. Brown
Program Manager, Environmental Compliance Office
TDOT Environmental Division

Cc:
Jim Ozment, TDOT
John Nichols, TDOT
Project Files

City of Memphis
TENNESSEE

A C WHARTON, JR. - Mayor
GEORGE M. LITTLE - Chief Administrative Officer
DIVISION OF PUBLIC WORKS
DWAN L. GILLIOM - Director
Storm Water Program

February 24, 2014

Ms. Vicki S. Steed, P.E.
Tennessee Department of Environment and Conservation
Division of Water Resources
Watershed Management Section
William R. Snodgrass Tennessee Tower
312 Rosa L. Parks Avenue, 11th Floor
Nashville, TN 37243

Subject: Draft of Proposed Total Maximum Daily Load for Arsenic Nonconnah Creek Watershed (HUC 08010211); January 17, 2014

Dear Ms. Steed:

The City of Memphis respectfully submits the attached comments to the referenced document for your consideration. Please do not hesitate to contact me at 901-636-4349 to discuss.

Sincerely,

Tasha King-Davis

Tasha King-Davis, P.E.
Stormwater Program Manager
City of Memphis

2714 Union Avenue Extended, Suite 625 • Memphis, Tennessee 38112 • (901) 636-4349

Comments on Draft Proposed Total Maximum Daily Load for Arsenic for the Nonconnah Creek Watershed (HUC 08010211) dated January 14, 2014

- In Paragraph 1 of Section 2.0 Watershed Description, the TMDL states the following: "*For the purposes of TMDL development, waters flowing into Tennessee from Mississippi are assumed to meet Tennessee water quality standards at the state line.*" What justification, if any, can TDEC provide to support this assumption? In particular, nearly 80% (approximately 42 of 54 square miles) of the Horn Lake Creek watershed listed in the TMDL is located in Mississippi and includes the urban areas of Southaven and Horn Lake. Also, TDEC's own sampling location (HLAKE004.0SH - located approximately 3,500 feet downstream of the state line) on Horn Lake Creek showed 8 exceedances over 27 samples. Finally, the Final 2012 303(d) list specifically notes "sources outside of the State" as a pollutant source. We request that the Horn Lake Creek segment should be removed from the TMDL until sources and potential impairments from outside the State are properly incorporated into the analysis.

- In Section 2.0 Watershed Description, Page 2, final paragraph; TDEC notes its use of land use information from 2001 as the best available data set while also noting the likelihood of changes due to rapid development in the watershed. Did TDEC inquire from any local sources for updated land use information (Shelby County, Memphis, DeSoto County, etc)? The analysis should not be based on nearly 13 year old data and should be updated to incorporate land use consistent with current conditions.

- TDEC notes in Section 6.0, Page 13 of the TMDL that "an important part of the TMDL analysis is the identification of individual sources, or source categories, of arsenic...." Further in the document, in Section 8.0, TDEC states "This condition is primarily the result of discharges from urban areas." Where is the supporting documentation that the MS4 is the primary source of pollutants? There is no evidence provided in the TMDL that the City of Memphis MS4 is a source of arsenic. The rationale appears to be speculative, at best.

- It does not appear that the potential for legacy pollutants to enter the stream have been addressed in the TMDL. What consideration, if any, was given to the potential contribution of scour from legacy sediments?

- While arsenic is naturally occurring, higher levels of arsenic can also come from known air and industrial sources. Was this evaluated?

- On Table 5, Page 17, there is a "c" superscript above "LAs" in the column heading of the table. It would appear to reference a footnote that does not exist. Should there be a footnote "c" below the table?

- In Section 8.0, Paragraph 3; TDEC recommends that water quality testing be performed for Horn Lake Cutoff to confirm the status of the segment as impaired. It goes on to state the following: "No monitoring data was available for this waterbody." Furthermore, on Page E-

2, the TMDL states, "The condition of the Horn Lake Cutoff could not be determined due to lack of monitoring data." Why is this segment included in the TMDL if TDEC acknowledges that no water quality testing data exists for the waterbody and that the condition of the waterbody could not be determined? If no data exists, we request that the Horn Lake Cutoff segment be removed from the TMDL until TDEC performs the proper analysis to identify the segment as impaired.

- Who is TDEC recommending to perform the water quality testing in Section 8.0, Paragraph 3? Would this responsibility fall on the MS4s? We believe it is the State's obligation to assess the condition of State waters to determine the appropriateness of a 303(d) listing or a TMDL development. This is not a municipal obligation.
- Section 8.1, Paragraph 1, Sentence 2; regarding MS4s, TDEC uses the term "cause or contribute" related to violations of water quality standards. Revised regulations promulgated by the State regarding anti-degradation purposely removed the "or contribute" language with such intent clearly evidenced in the rulemaking response to comments (reference Rule 1200-04-03-.06(2)(a)(1)). As such, we request that the "or contribute" phrase be removed throughout the TMDL.

APPENDIX H

Response to Public Comments Received

TDEC thanks NRCS for their interest in reviewing the draft version of this TMDL. We are pleased that they found it to be informative and hope it will be useful in the future.

TDEC has considered the comments submitted by TDOT and reviewed the studies cited by TDOT. The TDOT MS4 will not be considered as a potential source of arsenic loading. Changes have been made to Section 6.1.1 summarizing the arguments made by TDOT.

Response to comments from City of Memphis (numbers correspond to bulleted comments by the City of Memphis):

1a. TDEC recognizes that portions of the Nonconnah Creek watershed lie in Mississippi and that, even in Tennessee, portions of the watershed fall under the jurisdiction of different entities. Each local MS4 is responsible only for contributions of arsenic within their own boundaries.

The State of Mississippi's water quality standard for arsenic is 24 μg/L, which is more than double the water quality standard in Tennessee. Therefore, the portion of Horn Lake Creek in Mississippi has not been assessed as impaired due to arsenic. The language in paragraph 1 of Section 2.0 has been changed from "assumed" to "expected".

If Mississippi was contributing to the impairment, monitoring data close to the state line would confirm this. Examination of monitoring data collected at the mouth of Horn Lake Creek (HORN000.0SH) and monitoring data collected near the state line (HORN004.0SH) suggests that the source of impairment is, or was, upstream of the state line. 24 samples were collected between 2001 and 2011 at both locations on the same day. There were 9 exceedances at HORN004.0SH, while there were only 5 exceedances at HORN000.0SH. Of the 9 exceedances at HORN004.0SH, only one value was lower than the corresponding value at HORN000.0SH (on 7/24/01). However, analysis of monitoring data for HORN004.0SH also suggests improvement. Of 13 samples collected in 2001-02, there were 7 exceedances. Of 12 samples collected in 2010-11, there was only 1 exceedance. It is possible that Horn Lake Creek will be removed from the 303(d) List during the next assessment.

Tennessee has no jurisdiction over discharges in other States. Therefore, Tennessee will be coordinating with Mississippi to address the issue of arsenic entering Tennessee via Horn Lake Creek.

1b. As stated in Section 1, TMDLs must be developed for all waterbodies not attaining water quality standards as indicated by their inclusion on the 303(d) List. This is a requirement of the Clean Water Act. EPA's *Report of the Federal Advisory Committee on the Total Maximum Daily Load Program*, EPA 100-R-98-006 states "lack of certainty must not delay TMDL development" (USEPA, 1998). According to EPA's *Guidance for Water Quality-based Decisions: The TMDL Process*, EPA 440/4-91-001, "Lack of information about certain types of pollution problems (for example, those associated with nonpoint sources or with certain toxic pollutants) should not be used as a reason to delay implementation of water quality-based controls" (USEPA, 1991).

TMDLs are developed based on all information available at the time. If additional monitoring data is available that was not available at the time of the assessment, this new data is taken into account when developing the TMDLs. Sometimes the newer data suggests that a waterbody previously on the 303(d) List is no longer impaired. In that case, a TMDL, WLA, and LA are developed (because it is currently listed as impaired), but it is suggested that the waterbody be delisted.

As stated in the TMDL document, the target load for a given waterbody is equal to the TMDL and the TMDL is a function of the water quality standard and the daily mean in-stream flow. Calculation of the TMDL does not take into account monitoring results and additional monitoring data will not change the TMDL for a given waterbody. However, the required load reduction is based on monitoring results. When additional monitoring representing all seasons and a full range of flow and meteorological conditions has been obtained, required load reductions may be revised.

The purpose of the load reduction (PLRG) is to facilitate implementation. Waterbodies with a higher PLRG can be given a higher priority for allocation of resources. For each waterbody, the flow zone of the load duration curve with the highest PLRG can be targeted. Use of the resources contained in the TMDL document can enable the MS4 to target their resources more effectively and reduce unjustified and unnecessary financial and manpower burdens. WLAs and LAs are expressed on a unit area basis to allow for changing boundaries of MS4s.

2. TDEC is aware that development in the Memphis area has been extensive in the past twelve years. We were not aware that digital forms of more recent land use data might be available through the City of Memphis and Shelby County. Land use data is most useful in determining sources of impairment and appropriate locations for application of BMPs. More recent land use data will not impact either the TMDL or the required load reduction values.

3. Over 50 percent of the drainage area of the Nonconnah Creek watershed in general, and Cypress Creek and Horn Lake Creek in particular, is classified as urban area. Therefore, it is reasonable to assume that the source of the impairment is from urban area. As stated in section 6.2 paragraphs 2 and 3, historic use of arsenic-containing pesticides and treated lumber are common sources of arsenic that can be found in urban areas.

4. TDEC is not aware of any legacy sources of arsenic. Therefore, scour from legacy sediments was not considered. If information is available to suggest a legacy source, please provide that information.

5. Arsenic can also come from air and industrial sources. If the source of arsenic was airborne, the area effected would be more widespread and would include portions of Nonconnah Creek itself. Historical monitoring of Nonconnah Creek indicates possible impairment in the past. However, more recent monitoring of Nonconnah Creek indicates no impairment. As stated in Section 6.1.1, stormwater from regulated industrial facilities are a potential source of arsenic. However, there are no facilities covered under an individual stormwater permit, and the only facility covered under the TMSP general permit has been monitoring their discharges and there have been no exceedances.

6. The superscript "c" should have been a "b". The TMDL document has been corrected.

7. See response 1b above.

8. The City of Memphis is correct. The water quality monitoring recommended in Section 8.0 paragraph 3 is not a municipal obligation. However, if a waterbody is impaired due to MS4 source loading, the MS4 is responsible for determining source contribution, implementation of BMPs, and ultimately monitoring to assess effectiveness.

9. Occurrences of "or contribute" have been removed from the TMDL document.

Monitoring of permitted discharges to a waterbody is the responsibility of the permittee. If a permittee wishes to prove that they are not a source of the impairment in question, there are two options: (a) monitor permitted discharges to show that they are not contributing to a condition of impairment; or, (b) monitor the waterbody in question as it enters and exits their jurisdiction to show that the condition of the waterbody does not change by passing through their jurisdiction.